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POWER

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The Electric Boiler

PUMPING the water back over the dam used to be signalized as mechanical absurdity comparable to lifting one's self by one's bootstraps.

The difference is that one can pump the water back over the dam and in certain cases it pays to do it.

If water must be allowed to run down at a time when there is no use for it, the energy of its fall may profitably be employed to pump some of it back for use when a demand exists for power.

Another way of storing or using power that would otherwise go to waste is by the use of the electrical boiler.

Some of our readers, aroused by accounts of boilers of considerable capacities being operated by electricity in the industries, have visualized industrial boiler rooms with all the white-tiled luxury of a tonsorial parlor, where control and operation would require nothing more than the operation of a switch.

If there were plenty of energy going to waste, it might be done, but not on current generated by the combustion of fuel.

A kilowatt-hour is equivalent to only 3,413 B.t.u. and it takes the best stations between one and two pounds of coal to put a kilowatt-hour onto the switchboard.

In one pound of good coal the customer would get four times as much heat as he would in a kilowatt-hour of electricity.

In other words, the generating station would have to burn four or five times as much coal, to say nothing of the other expenses, to deliver to the customer as much energy as he could buy in a single pound of coal.

There is more convenience, cleanliness and efficiency in using the electricity than the coal, and so for many minor purposes, and even for cooking and heating to some extent, electricity may be and is used, especially in the household.

There are also large industrial operations in which the electric furnace is necessary, but its use for making steam in large quantities is practicable only where electrical energy is available which would otherwise go to waste.

F. R. Low

POWER *Stands for . . .*

1. Making Power When It Should Be Made
2. Buying Power When It Should Be Bought
3. Cheaper Power Through Modern Equipment
4. Easier Financing of Equipment Purchases
5. Better Use of Byproduct Heat and Power
6. Operating Methods That Save Money
7. Less Waste in Transmission and Application

What Does the Coal-Dust Engine Offer?

AS ENTRANCING as the search for the philosopher's stone have been the alchemists' attempts to turn coal directly into electric energy without the presence of a mass of conversion machinery. Chemistry has performed too many seeming miracles for one to deny the possibilities of the direct conversion, but it would seem that the coal-dust engine is the nearest approach that can be expected during this generation.

Since Watt's invention of the condensing engine, designers have added a detail here and there until not only the layman, but likewise a large number of engineers find the mass of accessories placed between the coal bin and the switchboard not so much an indication of engineering advancement as a proof of man's inability to deal directly with nature's forces.

The internal-combustion engine avoids much of the steam plant's complication, but cheap liquid fuel is not available everywhere. Coal is more widely distributed than petroleum and usually is much cheaper on a heat-unit basis.

We have, then, the efficient, simply constructed internal-combustion engine using a relative costly fuel and the complicated steam plant whose inefficiency is offset by its use of a cheap fuel. It was the combination of the simplicity of the internal-combustion engine and the burning of cheap fuel that set Doctor Diesel upon the research that led to the Diesel oil-burning engine. His first choice, a coal-burning engine, was a failure—not because the idea was wrong, but because of his inability to deliver coal dust into the cylinder. Efforts to make use of coal dust directly did not end with Diesel's failure, for both here and abroad experiments have been carried on by a number of investigators.

Out of this has appeared what impartial engineers declare to be a practical coal-dust engine. The Pawlikowski engine is workable, but the question to be answered is, What is its field of application?

In plants of small horsepower the cost of fuel is not the large item—the labor cost is the important part of the operating cost, and a reduction of fifty per cent in the fuel cost of a two-hundred-horsepower Diesel plant would be not over fifty cents per hour. The gain would not justify the addition of a coal pulverizer and the necessary engine alterations, for the overhead on the cost of the change would be more than the fuel savings. The same argument applies to a small steam plant, in which a change to an oil-burning engine would offer greater savings.

When plants reach a thousand horsepower, the coal-dust engine has possibilities. The fuel costs become important and the higher type of the operating force insures reliable service. Such plants, when located where coal is cheap and oil high in price, are the logical users of the coal-burning engine. Having an efficiency superior to that of the largest superpower plant and burning the cheapest coal, the coal-dust engine may become a deciding factor in the contest between the factory power plant and purchased energy.

From Cherry Blossoms to Fuel

JAPAN is pictured as the land of nimble-fingered craftsmen, cherry blossoms and silk kimonos. She is all of these but more. For today the Japanese genius for fine work and thoroughness is finding other fields of expression. The island empire faces the great problem of feeding and clothing its swarming millions. Her industries must have power and raw materials. Hydroelectric developments are springing up all over Japan, but coal must likewise be used for power, industrial heat and chemical products.

Japan realizes the key position of fuels in the industrial structure and is preparing, through scientific research, to make the utmost use of her natural resources of combustible materials. To quote from Maurice Holland, writing in the current issue of the *Atlantic Monthly:*

> One of the most important and extensive of the national laboratories supported by the government is the Imperial Combustibles Research Laboratory—another result of Japan's determination to utilize to the highest degree her natural resources. As one engineer expressed it, "Japan's limited coal supply makes it imperative for us to develop scientific methods for obtaining every atom of energy from our available supply."
>
> This laboratory is divided into several sections, which are specifically charged with the exact determination of the nature and structure of coal, the development of low-temperature carbonizing processes, the development of coal derivatives, the utilization of brown coal, and the extraction of oil from shale. The work of the Institute is important not to Japan alone, but to the entire world. American and European engineers who have followed the laboratory's work agree that Japan is gaining world leadership in the field, and that in the future other countries will look to the East for knowledge of combustibles.

Japan's real contact with scientific Western civilization began in 1854, when Commodore Perry succeeded in establishing treaty relations with the United States. If Mr. Holland is right and Japan is now gaining world leadership in the field of scientific fuel technology, it is a truly remarkable performance.

Less Waste in Application of Steam for Heating

IT IS seldom desirable to maintain uniform temperatures throughout a manufacturing plant. Frequently, in the shipping rooms a much lower temperature is allowable than in the rest of the manufacturing space, while in the offices a higher temperature must be maintained because of the more sedentary form of occupation.

In other parts of the plant the heat supply ordinarily required to maintain comfortable conditions may be made entirely unnecessary because of heat emitted by a forge or other mechanical equipment.

Then, too, there is a considerable variation in the heat loss through opposite building walls because of the action of wind and sun.

One way to correct for such variations in heat requirements is by zoning so that the heat supplied to the various parts of the building may be separately controlled and adjusted to meet the demand. The savings obtainable by zoning a steam-heating system are well illustrated by an article in this issue.

There Is No Rule of Thumb

THE old saying, "There is no royal road to success," might be paraphrased to read, "There is no royal road in motor and power-transmission equipment selection." The old idea that some day there would be a universal motor has been badly shattered. Today a greater variety of equipment is available for power drives than ever before, and the list is increasing. At one time an individual motor connected directly to its load was looked to as the future method of driving machines. After years of experience it has been found that this method does not always work out to the best advantage in practice.

Many of the old group drives were horrible examples of how power drives should not be laid out and maintained. They were not only unsightly and inefficient, but seriously interfered with production methods. On the other hand, the idea that individual motor drives always have a high efficiency and group drives a low efficiency can not be substantiated by a careful analysis or by experience.

Small motors have a low efficiency, and if of the alternating-current type, they also have a low power factor. This condition may be further aggravated by the difficulty of keeping the individual motors loaded. With group drive a large motor can be used, which has a high efficiency and a much better power factor than the small motors. Grouping the load allows taking advantage of the diversity factor to reduce the total horsepower and to obtain a better loading of the motor.

Power factor may be of greater importance than efficiency, as it may not only lower the efficiency of the system, but also cause poor voltage regulation and overload the generating and transmitting equipment and increase the power costs. With large motors the possibilities for controlling the power factor are superior to those with small motors.

Considerations involved in the selection of a motor drive reach farther than the individual machine. They begin in the power house and end in the quality and cost of the manufactured product. To obtain the drive that will give the lowest cost, all things considered, should be the goal. This may be individual drive or it may be group drive or a combination of the two. There is no rule of thumb to answer this question. A careful analysis and sound judgment must be the guide if the best results are to be obtained.

Efficiency in Spots—Why?

THE pursuit of efficiency is hampered by many fads and inconsistencies. When the plant is designed, great emphasis may be placed on high efficiency in the generating equipment. In the application of the power, high efficiency in the motors may be insisted upon, with little attention given to the influence of the wiring system, the motor loads, alignment of shafting, condition of speed reducers and other equally important factors.

If high efficiency is of prime importance in one part of the power generation and application, it should be so in all. It is of little use to incur expense to gain one-half per cent in generating-equipment efficiency, if several times this saving is wasted in distribution and application. This is particularly true when this waste could be avoided with a reduction in installation cost.

A twenty-five-horsepower motor on a ten-horsepower load will result in a loss of three or four per cent in efficiency in the motor, not considering the unnecessary cost incurred in buying a motor too large for the load. If the machine is of the alternating-current induction type, the increased current due to low power factor also causes a loss in efficiency in the distribution lines, the transformers and the generators. Losses totaling four or five per cent plus waste investment in unused capacity, may thus be chargeable to selecting a motor too large for the load.

If large, slow-speed induction motors are installed where synchronous motors should be used, they result in a considerable loss of efficiency in supplying the power to the load. In some installations synchronous motors are used to drive equipment that is required only a small part of the time, where it is desired to keep the motor in operation to correct power factor. The losses in the driven equipment during the idle periods can be saved by the use of a clutch to disconnect the motor from its load.

Many other installations offer opportunities for saving, but are frequently neglected even when money and effort are spent to produce power efficiently. If high efficiency is worth going after, it should be applied to the whole system and not in spots.

THE COAL-DUST ENGINE

Details of the Design

By L. H. Morrison
Associate Editor, Power

THE successful operation of the Pawlikowski powdered-coal engine proves that Doctor Diesel's original patent on an internal-combustion engine was based on sound logic, even though he had to turn to oil to make the Diesel engine function. Rudolf Pawlikowski was associated with Doctor Diesel in the early days of oil-engine construction and continued to experiment with the attractive idea of burning cheap coal in an engine. That the two engines now using coal dust at Gorlitz, Germany, are beyond the experimental stage is attested by impartial American engineers who have seen the machines in operation. A brief description of the Pawlikowski engine appeared in *Power*, July 24, 1928, but the constructive details were not shown. As was then outlined, the first Diesel adapted to powdered coal was a single-cylinder unit, 16½-in. bore by 25-in. stroke, rated at 80 hp. To this has since been added a three-cylinder unit of 180 hp. capacity.

The cross-section of the engine, Fig. 1, shows the pulverizing equipment belt driven from the engine, although in the actual engine the grinder is motor driven. The grinder is located at *a* and the coal is crushed so that about 80 per cent will pass through a 100-mesh screen. The blower *b* delivers this to a separator above, and the coarse particles are led back to the pulverizer while the fine dust, along with some air, passes into the chamber *d*, out of which a return line leads back to the pulverizer. As will be seen from the illustration, a set of ports in the cylinder walls, when uncovered by the piston, permits hot exhaust gases to pass into the hollow baffling of the coal hopper. In this way the coal is dried before crushing. The original patent also embodied the use of the warm jacket water for the same purpose.

There is, in the chamber *d*, a mass of coal dust intermixed with air. This feeds down into the screw conveyor *F*. It will be seen from Fig. 2 that two conveyors are used; one to move the coal to the fuel valve and the second to return any that does not enter the valve. In other words, there is a constant stream of fuel flowing to and from the fuel valve, and the speed of the screws is such that the air is kept mixed with the dry coal dust.

The details of the fuel valve can be seen in Figs. 2 and 3. The valve consists of a body surrounding two movable valves *P* and *G*, and this assembly is immediately above the combustion chamber *L*.

As the coal passes along the conveyors at atmospheric pressure, means must be used to bring the fuel cavity between the valves *P* and *G* to this pressure so that the fuel will enter the cavity. Consequently, the spindle *O* of the inner valve *G* is hollow, and, as indicated in Fig. 4, when both valves are seated, any gases in the cavity can pass through *O* to the atmosphere.

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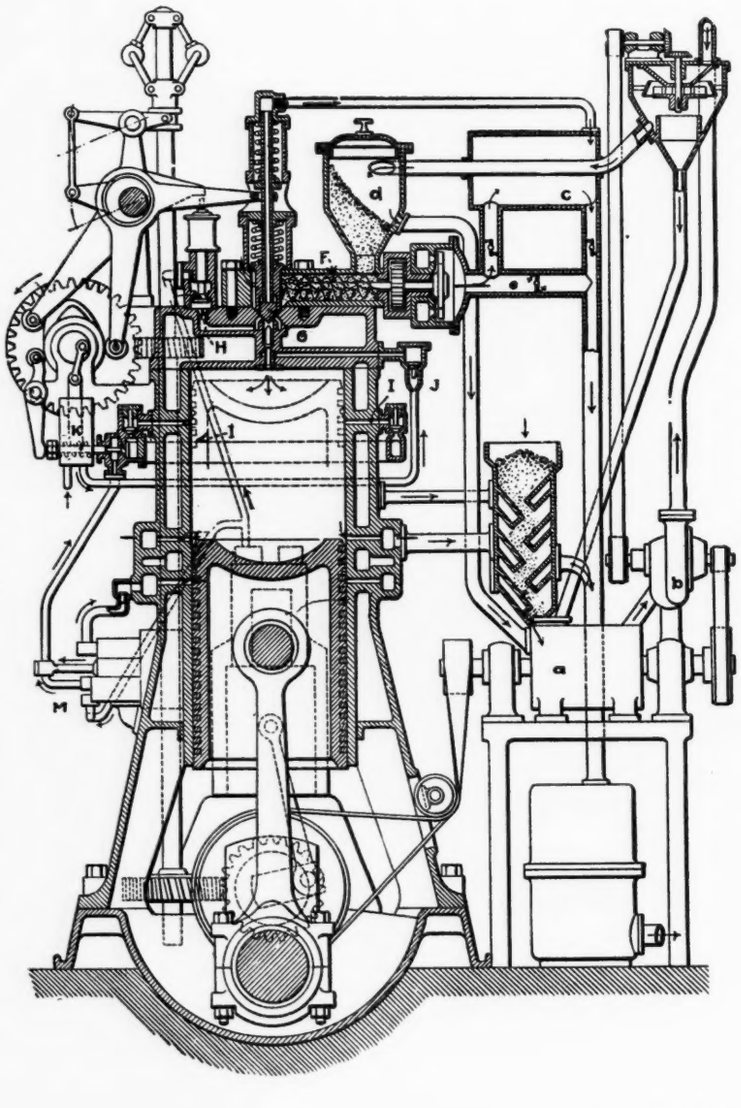


Fig. 1—Cross-section of the Pawlikowski coal-dust engine

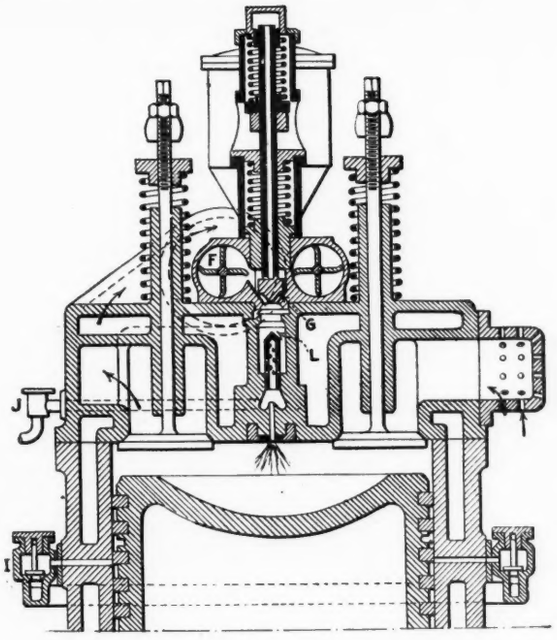


Fig. 2—The design of the cylinder head and fuel feeding mechanism

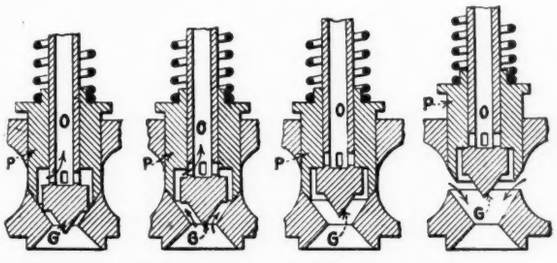


Fig. 3—Action of the fuel valve during the charging period

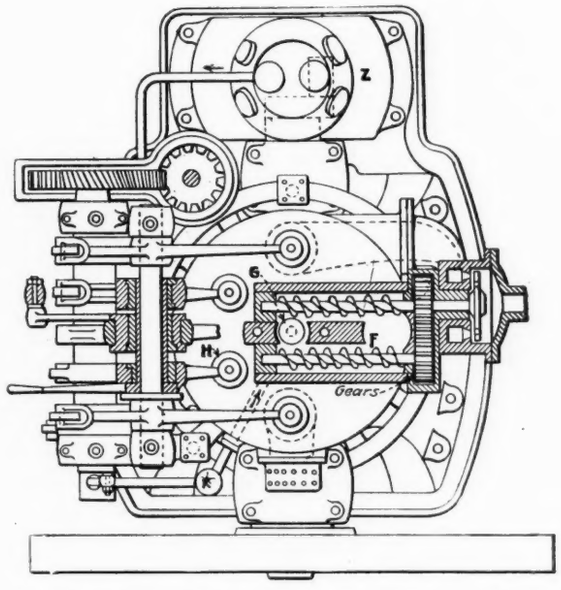


Fig. 4—The cylinder head as viewed from above, with the feed screws shown in action

piston, the fuel valve arm lifts valve *G* and any pressure in the combustion chamber is relieved through the passage *O*. Continued lifting of *G* causes it to raise the outer valve *P* and seal the relief ports, as shown in Fig. 3, after which action coal from the screw conveyor enters the valve cavity and drops into the combustion chamber *L*.

During the compression stroke the coal particles are heated to probably 800 deg. F., and there is no doubt that a partial distillation occurs. At or close to top dead center, a fuel pump *K* injects a minute ignition oil charge through the line *J* into the lower end of the chamber *L*; at the same time the valve *H* is opened and a charge of high-pressure air enters *L* and blows the coal dust and the ignition oil into the cylinder. There the ignition of the oil insures the ignition of the coal charge.

The combustion of the fuel charge proceeds as in a Diesel engine, and the piston moves on its power stroke. At approximately bottom dead center the hot gas ports leading to the coal drier are uncovered, and at the same time air from a scavenging pump at *M* blows a stream of air through the lower set of ports, shown in Fig. 1. This serves to blow all ash from the piston. It has been found that air is not needed and that ash is kept off the piston through the use of more lubricating oil, which is later reclaimed. On the exhaust stroke air is blown through the ports *I* to scour all ash off the top end of the piston and force it out the open exhaust valve. From experiments with and without these air jets, it has been found that the lubrication within the cylinder keeps the ash from depositing on the piston and cylinder walls.

The success of the engine is due primarily to the design of the coal-dust fuel valve and to the use of a small charge of oil to insure ignition. In former designs the coal dust caked and refused to enter the fuel valve. The constant flow of the coal and air mixture along the screw conveyors eliminates this.

One hesitates to predict a wide use of this type of engine, but it seems to have obvious advantages, in that either coal or oil can be used, depending upon the price of the two fuels. A standard Diesel can be altered to use coal dust at a cost ranging from five to ten dollars per horsepower, depending upon the size of the unit.

The rate of wear of an internal-combustion engine is dependent upon the distance moved by the rubbing surfaces, given equal surface-hardness, loadings and lubrication. The distance moved by the rubbing surfaces in the same time do not differ greatly in high- and low-speed engines of equal power, but the small engine has much harder working surfaces and is usually far better lubricated. Moreover, it is much stiffer as a structure, so that the alignment of bearings is better maintained. The rate of wear in terms of metal lost per hour is, on the whole, rather less in the light high-speed engine, but on the other hand this engine cannot afford to lose so much metal without loss of efficiency; hence parts need more frequent renewal. The cost of replacement per unit weight of metal lost, however, is about the same in either case, while much more time is taken to effect replacement in the larger engine. Thus, while the small high-speed engine requires more frequent overhauls, the aggregate cost and loss of working hours due to these overhauls will be substantially less over any given period than it will be for the low-speed engine. In addition the small high-speed engine is almost immune from failures due to heat stresses in the material, it is much cheaper in first cost, occupies less space, and is more easily installed.

Burning Powdered Coal

In Diesel Engines

Suggested By

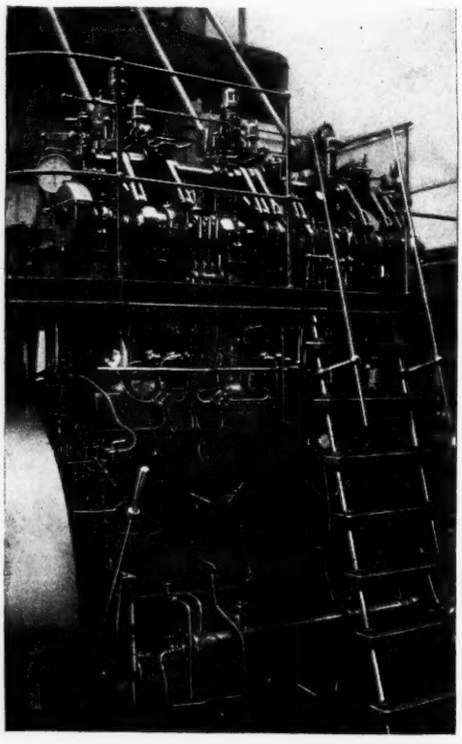
H. SCHRECK

PROGRESS and time will work incessantly toward the use of more economical prime movers. Competition forces a reduction in production costs which compels the engineer to study the various items of cost, one of which is the cost of power. For the last fourteen years this problem has been studied more intensively than ever, and engine builders and scientists have put forward their best efforts to reduce this item by the advancement of highly developed and more economical prime movers, such as, by raising of steam pressure, the use of highly superheated steam, mechanical stokers, powdered coal and other means. There is, however, another development that offers far greater possibilities—the use of powdered coal in Diesel engines.

It is well known that the thermal efficiency of the internal-combustion engine is higher than that of the steam plant, and yet the internal-combustion engine as a prime mover has so far conquered but a small field, at least so far as stationary engines are concerned.

The reason for this failure is plain. It is the low cost of coal against the relatively high cost of fuel oil in a large portion of this country and still more so in most European countries, where the fuel oil must be imported and where coal is a home product. The cost of fuel for steam and internal-combustion engines will be shown for comparison by a few figures on the heat-unit basis. Let it be assumed that we have a coal of 12,600 B.t.u. per lb. and its cost is three dollars a ton delivered at the power house, and a fuel oil of 18,500 B.t.u. per lb. at a price of five cents a gallon at the plant. On this basis 1,000,000 B.t.u. will cost 11.9c. for coal and 33.7c. for fuel oil, or, in order to produce power at the same price, the efficiency of the oil engine must be about three times that of the steam engine if the prices of the two fuels are as stated.

The price of coal against that of fuel oil will, therefore, decide either in favor of a steam engine or in favor of an oil engine, all other conditions being similar. A study of the effect of variation in price of fuel reveals some interesting facts. A Diesel engine has a fuel consumption, considering partial loads, of 0.46 lb. per hp.-hr.: at a generator efficiency of 87 per cent there will be produced 10.7 kw.-hr. per gal. of fuel oil, making the cost of fuel per kilowatt-hour at different prices of fuel as shown in Table I.



The coal-dust engine

On the same basis the cost of coal for a steam plant will be considered. The coal consumption for all purposes varies in steam-turbine plants between 1.5 and 2.5 lb. of coal per kilowatt-hour. There are figures on record of one pound of coal for the Columbia plant in Cincinnati, but these are test figures which cannot be produced month after month, and furthermore, they were for a plant of large capacity, which does not fall within the scope of this article.

Reciprocating steam engines show a coal consumption for all purposes between three and six pounds of coal per kilowatt-hour and on this basis the cost of coal per kilowatt-hour is given in Tables II and III.

These prices cover only the cost of the fuel, and the fixed charges, cost of labor, maintenance and water must be added to get a true comparison of the cost of power production, but this, of course, is a matter for a separate study. However, when for any locality or condition the prices of coal and fuel oil are known, these tables will readily show when, on the fuel basis alone, an oil engine and when a steam engine will come under consideration.

In other words, a low price for coal puts the Diesel engine out of the running, and these figures show clearly why Diesel engines are used to such great advantage in certain parts of the country and under certain conditions, while on the other hand they offer no advantage where coal is cheap.

If the simplicity of service inherent in the Diesel engine and the low price of fuel can be combined, the

answer to a far broader application of the Diesel engine and cheaper production of power is given. Such a unit is now being presented by the Diesel engine operated on powdered coal.

This engine, as developed and operated in Germany, has a fuel consumption of 0.66 lb. of coal per brake-horsepower-hour or about one pound of coal per kilowatt-hour, when operated with a coal of 12,600 B.t.u. Table IV shows the fuel cost with the powdered-coal engine.

TABLE I—COST OF FUEL OIL PER KILOWATT-HOUR FOR DIESEL ENGINES

Price per gallon	$0.025	$0.04	$0.05	$0.0715
Price per kilowatt-hour, in mills	2.34	3.74	4.67	6.66

The fuel cost of the Diesel engine operated on powdered coal falls even below the lowest figures of fuel cost in large central power plants operated with high pressure and superheated steam. The Diesel then becomes the most economic prime mover when operated on coal in territories where coal is low in price, and when operated on fuel oil where fuel oil is low in price.

TABLE II—COST OF COAL PER KILOWATT-HOUR
(Turbines with high-pressure superheated steam)

Coal rate, lb. per kw.-hr.	1.5				2				2.5			
Cost of coal per ton, dollars	2	3	4	5	2	3	4	5	2	3	4	5
Cost of coal per kw.-hr., mills	1.5	2.25	3	3.75	2	3	4	5	2.5	3.75	5	6.25

A vertical single-cylinder 80-hp. engine was inspected by the writer last year in Germany, where it was driving the factory of the manufacturer and had been doing so continuously since 1921. This engine has been operated on all kinds of coal, including lignite and charcoal. During operation it can be switched from coal to fuel oil. Powdered coal has been used in this engine with an ash content as high as 10 per cent, and the wear on the cylinder liner during all these years of operation has not been serious enough to require the installation of a new

TABLE III—COST OF COAL PER KILOWATT-HOUR
(Steam engine operation)

Coal rate, lb. per kw.-hr.	3				4				5				6			
Cost of coal per ton, dollars	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5
Cost of coal per kw.-hr., mills	3	4.5	6	7.5	4	6	8	10	5	7.5	10	12.5	6	9	12	15

cylinder liner. This engine was started in operation with powdered coal in 1916, and the liner must have had a certain amount of wear then, because this engine was purchased as a used engine.

Finally, comparing Diesel engine against Diesel engine, operated in one case on fuel oil and in the other case on coal, and assuming a cost of five cents a gallon for oil and a coal cost of three dollars a ton, and adding 75 cents per ton for pulverizing, the fuel cost of the engine

TABLE IV—COST OF COAL PER KILOWATT-HOUR
(Diesel engines operated on powdered coal)

Cost of coal in per ton, dollars	2	3	4	5
Cost of coal per kw.-hr., mills	1	1.5	2	2.5

operated on powdered coal is about one-third that of the Diesel engine operated on fuel oil.

These comparative outlines of fuel cost should prove how much the use of powdered coal will broaden the field of application of the Diesel engine as a prime mover, and also reduce the cost of production in the various industries by an appreciable amount. Builders could arrange their engines so that the change from oil to coal could be made with a minimum amount of expense and delay.

The Steam Engine's Position in the Marine Field

THE implication from much that is written is that the growth of motor-ship tonnage has been entirely at the expense of steam tonnage. But the facts do not bear out this contention. If it is asked whether to any degree motor tonnage has taken the place of steam tonnage, the answer must be in the negative, for what has actually happened is that both have gained at the expense of sail tonnage. Of the percentage decrease in sailing vessels since the beginning of the century, two-thirds has been replaced by steam vessels and only one-third by motorships. Nor must it be forgotten that into the whole question there has been introduced another factor, namely, tankers, which now account for 10 per cent of the total. A considerable percentage of this is actually motor driven.

When this century opened, 75.6 per cent of the total gross tonnage of the world was steam driven, the balance being still propelled by sails. Five years later the steam tonnage had increased to 83.24 per cent of the total, entirely at the expense of the decrease in sail and in 1910 to 88.97 per cent. In 1911 the first Diesel-engined overseas freighter, the "Selandia," appeared, and by 1914, the last pre-war year, steam was driving 92.01 per cent of the tonnage afloat and the Diesel 0.48 per cent. That under sail was only 7.51 per cent of the total, as compared with 24.40 per cent when the century opened. In 1920 steam-driven tonnage had increased to 92.38 per cent of the total afloat, motor-driven to 1.67 per cent, and sail was only 5.95 per cent. Five years later, in 1925, the percentage of steam-propelled to the total had decreased very slightly to 92.30 per cent, sailing had decreased to 3.50 per cent, and the difference had been made up by motor-tonnage, which was then 4.20 per cent of the total.

Today 89.21 per cent of the world's shipping is steam driven, 8.11 per cent is motor-driven, and 2.68 per cent is under sail. What has happened, then, from a consideration of these figures is that since 1910, when the Diesel was first looked upon as a sea-going possibility, the loss to sail of 8.35 per cent of the world's total shipping has been made good by an increase of 8.24 per cent in motor tonnage, steam taking the difference of 0.14 per cent. Steam tonnage has therefore not lost by reason of the advent of the Diesel engine except so far as the Diesel has taken the percentage of sail tonnage that would otherwise have been replaced by steam.

Operating Methods That Save

Good management can exist only when it is based on exact knowledge. Fuel, power, air and water, are used in large quantities in most industrial processes. Accurate records of how these materials are used is essential to intelligent management. The leading article of the November 13 issue throws a new light on the part that meters and measuring devices play in industrial plant management.

Factors That Influence
THE CHOICE OF A BOILER

By J. B. Crane
Combustion Engineering Corporation, New York

THERE are many types of boilers to choose from and the selection depends upon the kind of service. This article is limited to boilers for power generation, thus eliminating the cast-iron heating boiler, the fire-tube boilers for heating and small steam outputs at low pressure and for marine and locomotive purposes. The fire-tube type is extensively used for recovering waste heat, but this will not be covered here.

The following types of water-tube boilers are available: Horizontal, longitudinal drum with sinuous headers; horizontal, longitudinal drum with box headers; horizontal, cross-drum with sinuous headers; horizontal, cross-drum with box headers (these boilers may have either vertical or horizontal baffling); vertical and semi-vertical boilers with two or more drums.

The predominating feature is personal preference. The purchaser may be familiar with one type through years of experience or through contact with someone who is accustomed to this type. The experience has been satisfactory, another boiler is needed. Why change? Call up the company that furnished the original unit and order a duplicate. The spare parts are interchangeable, the fireman is familiar with its operation and the purchaser follows the path of least resistance.

However, suppose the boiler plant is outgrown. Larger output, increased pressures, greater economy, longer life, lower maintenance or some combination of these is desired—then the problem becomes more complicated.

As between vertical and horizontal boilers there is a wide divergence of opinion. In the East, decided preference exists for horizontal boilers; in the Middle West the preference is for vertical or semi-vertical boilers and in general this preference extends to the steel industry. Otherwise, the personal choice is dependent upon a study of the various factors involved. It is generally accepted that a horizontal boiler containing the same square feet of heating surface as a vertical or semi-vertical boiler, and operating below 300 per cent rating, will give lower exit temperatures at the same rating with similar conditions of firing. The advent of higher ratings and pressures combined with the use of economizers, air preheaters and water-cooled furnace walls has, however, changed the problem and made it necessary to consider the complete generating unit instead of only the boiler. This has been further complicated by the use of feed-water heating from turbine stage bleeding and the consideration of reheater location in cases where it is necessary to re-superheat the steam after passing through a part of the turbine or through the high-pressure turbine where turbines of two different pressures are used.

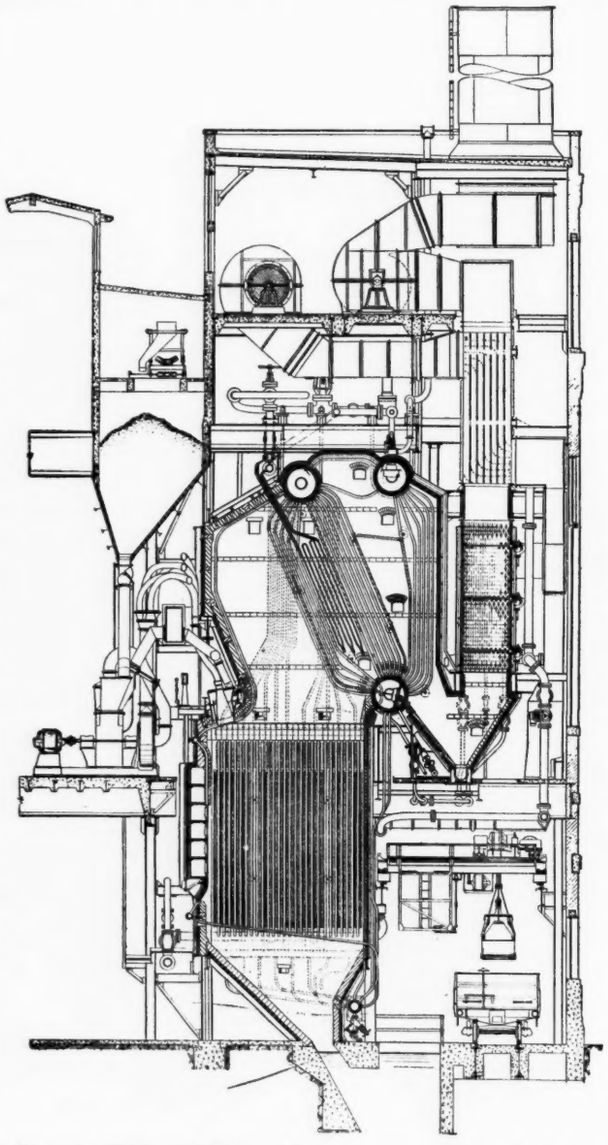


Fig. 1—This 1,400-lb. high-pressure boiler is being installed at the Northeast Station of the Kansas City Power & Light Company. It is of the Ladd semi-vertical type

The longitudinal drum boiler is limited to a maximum around 10,000 sq.ft. of heating surface. This type really consists of 2,500-sq.ft. sections connected at the bottom through the blowoff header and at the top by cross-connecting tubes. In the box-header boilers there is a little more intimate connection through the front and the rear headers, but the effect is the same. The center of the boiler is much hotter than the sides, the water in the center drum, being at less density, is higher than the water in the

side drums and great care must be exercised to arrange the feed and the blowdown to keep the concentration uniform throughout the entire boiler and to keep the water levels at a point that will prevent water going over with the steam.

Below this size there are no real points of difference between the two types of horizontal water-tube boilers except the fact that the cross-drum boiler will usually occupy less headroom and above 1,000 sq.ft. some are less expensive to build. This is a controlling factor in marine work, but not so important on land. The box-header boiler approaches a limit at around 12,500-sq.ft. of heating surface. The single plates for larger sizes are special and difficult to ship.

Power plants are today going to higher pressures. Five central stations have adopted approximately 1,400 lb. pressure; one industrial plant 1,800 lb., another 800 lb. pressure, and several central stations are running at 650 lb.

The writer believes that, above 450 lb. the only boilers to be considered are the cross-drum sinuous header and the vertical and the semi-vertical types. The foregoing discussion can be summarized in the accompanying table.

Consider the pressure range below 450 lb. and sizes less than 10,000 sq.ft. The problem is simple. The installation giving the highest efficiency evaluated for the cost will be the best investment. The only complication is fitting the unit into the available space and the method of firing. The vertical and semi-vertical boilers usually have an advantage for pulverized-coal firing inasmuch as the length of flame travel is longer than with a horizontal boiler unless the latter is set unusually high. The higher exit temperatures from the vertical or semi-vertical boiler are absorbed in the air preheater and give a greater rise in air temperature and consequently higher furnace temperature, better combustion conditions and lower carbon losses.

Sinuous-header horizontal boilers are always installed with vertical baffling. Box-header boilers are installed with either horizontal or vertical baffling. With the horizontal baffles parallel to the tubes, the tubes in a vertical plane can be placed closer together, and, by using hollow staybolts, the soot can be blown from the tubes through these staybolts. This method of construction is especially valuable where headroom is at a premium, as the vertical height is less than in the case of boilers equipped with vertical baffles.

The typical boiler exit gas temperature curve starts out with steam temperature at zero rating, rises slowly to 100 per cent rating, then more rapidly to 300 per cent rating, then slowly as the rating increases. It cannot, of course, reach the temperature of the gases in the furnace, and at high ratings the higher velocity over the heating surface gives a high rate of heat transfer. See Fig. 3 for exit temperatures of vertical and semi-vertical boilers and Fig. 4 for exit temperatures of horizontal boilers. In Fig. 4 a typical vertical boiler curve has been superimposed and it will be noted it is higher than the horizontal boiler at low ratings but lower at the higher ratings. This is undoubtedly due to better circulation in the vertical or semi-vertical boiler, each tube releasing the steam bubbles as fast as formed. As most boiler work has been around 100 to 300 per cent rating, this phenomenon has not been fully appreciated.

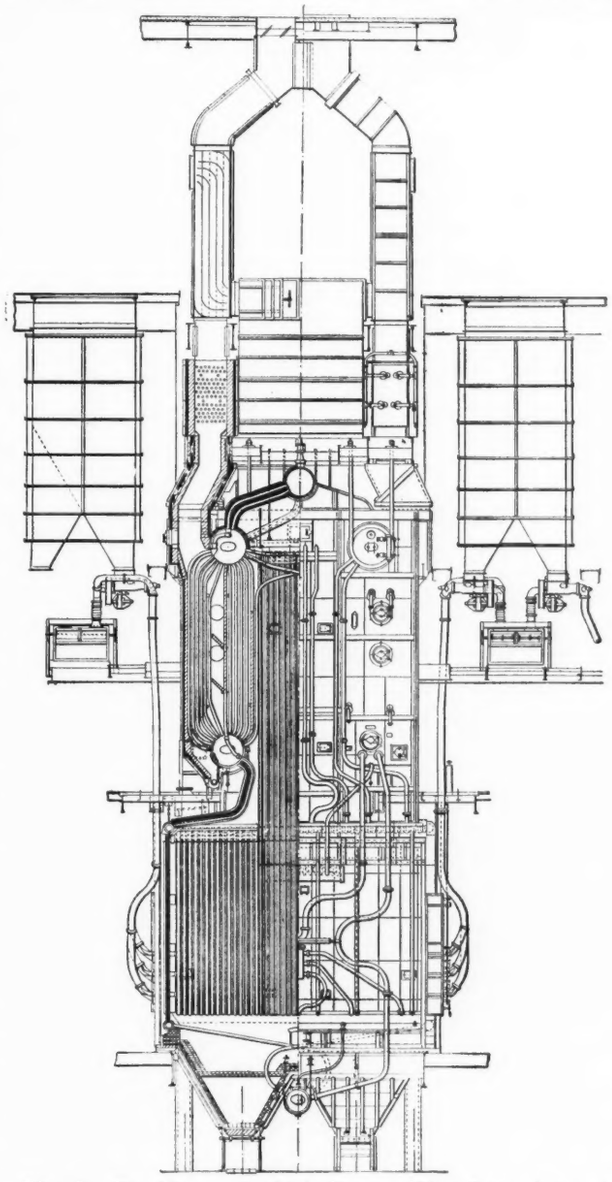


Fig. 2—Double-set Ladd boiler at Kips Bay plant of New York Steam Company. This has 16,950 sq.ft. of heating surface and a continuous capacity of 400,000 lb. of steam per hour at 275 lb. pressure

Fig. 5 gives a theoretical curve for higher ratings up to 1,500 per cent. The curve labeled Ford No. 2 and No. 4 is from tests on a double Ladd boiler containing 26,470 sq.ft. of heating surface and the furnace equipped with 3,300 sq.ft. of water-cooled furnace wall surface. The combined unit delivers, at normal rating, 97,000 lb. of steam, but usually operates at 570,000 to 600,000 lb. of steam per hour and has operated at 640,000 lb. Test temperatures are available on two units and the third unit, which has just been placed in operation, is giving slightly lower temperatures than the other two. If these units were operated at 1,500 per cent rating, the exit temperature would probably be not more than 930 deg. F. or 530 deg. F. above steam temperature. However, the draft loss through the boiler is now five inches and at 1,500 per cent rating would probably be 25 in. Therefore, we would undoubtedly open up the tube spacing to produce a lower draft loss and the exit temperature would be about 1,300 deg. F. or 900 deg. F. above boiler temperature. This exit temperature would be further reduced by an economizer and air preheater.

For single boiler outputs of over 300,000 lb. of steam per hour, as required in the modern station, double-set vertical or semi-vertical boilers offer the best possibilities. Horizontal boilers are limited to tubes 24 ft. long, and for high capacities the furnace width must be wide to

TYPES SUITED TO DIFFERENT SIZES AND PRESSURES

Pressure Less Than 450 Lb. Size Less Than 10,000 Sq.Ft. Heating Surface	Pressure Less Than 450 Lb. Size 10,000 to 12,500 Sq.Ft. Heating Surface	Pressure Over 450 Lb. All Sizes
Longitudinal drum		
Box header	Box header	
Sinuous header	Sinuous header	Sinuous header
Cross-drum	Cross-drum	Cross-drum
Vertical	Vertical	Vertical
Semi-vertical	Semi-vertical	Semi-vertical

accommodate the fuel-burning equipment and give the required furnace volume. With double-set boilers, the furnace width is kept to reasonable dimensions and the drums can be readily built with available machinery. The

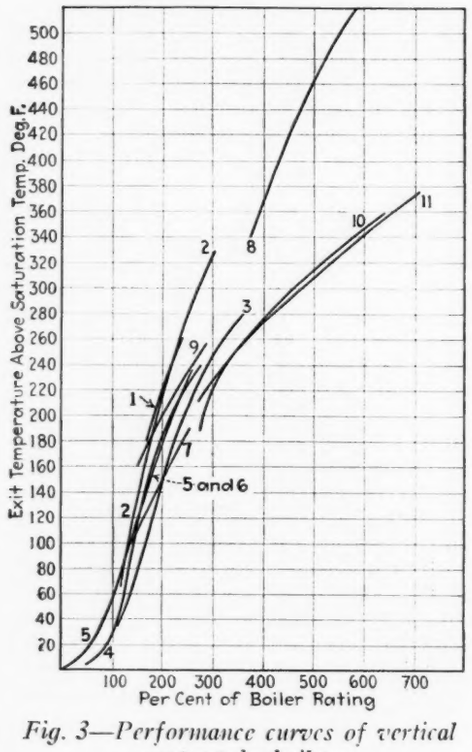


Fig. 3—Performance curves of vertical water-tube boilers

1. Three-pass, 16 tubes deep, pulverized coal, 7,688 sq.ft., H.S., 878 sq.ft. S.H.
2. Three-pass, 16 tubes deep, 1,500 sq.ft. H.S., 416 sq.ft. Rad. S.H.
3. Same as 2 except 1,700 sq.ft. Conv. S.H.
4. Same as 3.
5. Four-pass, 16 tubes deep, 835 sq.ft. bottom screen, pulverized coal 30,600 sq.ft. H.S., 4,520 sq.ft. S.H.
6. Three-pass, 18 tubes deep, stoker 8,120 sq.ft. H.S., 473 sq.ft. S.H.
7. Three-pass, 16 tubes deep, 927 sq.ft. water wall, pulverized coal 9,850 sq.ft. S.H.
8. Two-pass, 12 tubes deep, pulverized coal, 7,520 sq.ft. H.S.
9. Three-pass, no water wall, pulverized coal, 26,470 sq.ft. H.S., 3,140 sq.ft. S.H.
10. Three-pass, 3,014 sq.ft. water wall, 26,470 sq.ft. H.S., 3,520 sq.ft. S.H.
11. Same as 10.

furnaces are square or nearly so, which permits corner firing or opposed firing, if pulverized coal, gas or oil is to be used, or, to double stokers.

The draft loss at high ratings is lower with vertical boilers. This is quite important where either economizers or air preheaters or both are to be used. Tube renewals with such vertical boilers are readily accomplished by taking the tubes through the furnace, saving the space external to the boiler setting that is required to change tubes with horizontal-tubular boilers. This type of boiler gives a preferred location for a superheater. The superheater is usually placed between the tubes, suspended

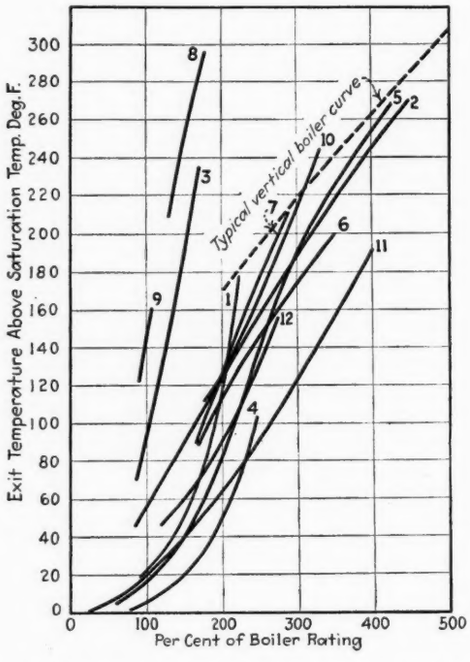


Fig. 4—Performance curves of various horizontal water-tube boilers

1. Cross-drum, 14 rows high, 27 wide, 8,220 sq.ft. H.S., 236 sq.ft. W.W.
2. Cross-drum, 15 high, 42 wide, 15,326 sq.ft. H.S., 3,860 sq.ft. S.H., 480 sq.ft. W.W.
3. Three-pass, 15 high 4-in. tubes 18 ft. long, 4,680 sq.ft. H.S., S.H. above tube bank.
4. Four-pass, 15 high, 38 wide, 20 tubes, 13,060 sq.ft. H.S., 320 sq.ft. W.W.
5. Cross-drum, 12 high, 54 wide, 22 ft. long, 18,900 sq.ft. H.S., 4,000 sq.ft. S.H., 460 sq.ft. W.W.
6. Long-drum, 24 high, 21 wide, 20 ft. long, 11,400 sq.ft. H.S., 1,485 sq.ft. S.H.
7. Fourteen high, 13,512 sq.ft. H.S.
8. Fourteen high, 6,000 sq.ft. H.S.
9. Ten high, 4,400 sq.ft. H.S.
10. Fourteen high, 12,000 sq.ft. H.S., S.H., Econ.
11. Eighteen high, 20 ft. long, 18,000 sq.ft. H.S.
12. Cross-drum, 20 high, 38 wide, 18,010 sq.ft. H.S., 4,070 sq.ft. S.H.

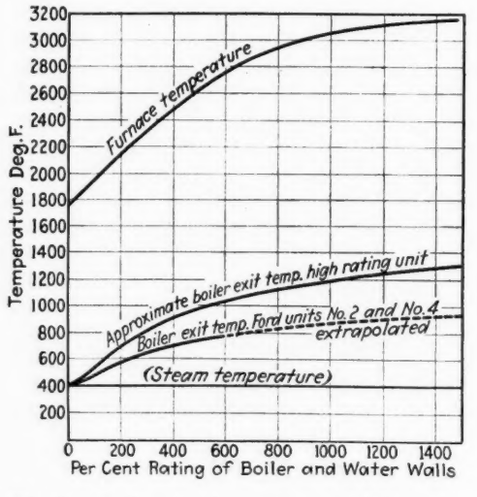

Temperature Deg. F.
Per Cent Rating of Boiler and Water Walls
Furnace temperature
Approximate boiler exit temp. high rating unit
Boiler exit temp. Ford units No. 2 and No. 4
extrapolated
(Steam temperature)

Fig 5—Boiler performance at high ratings

from above and extending parallel to the tubes in the front bank. The front tube of the superheater is placed one or more rows back of the furnace. This gives maximum protection for the superheater, the highest steam

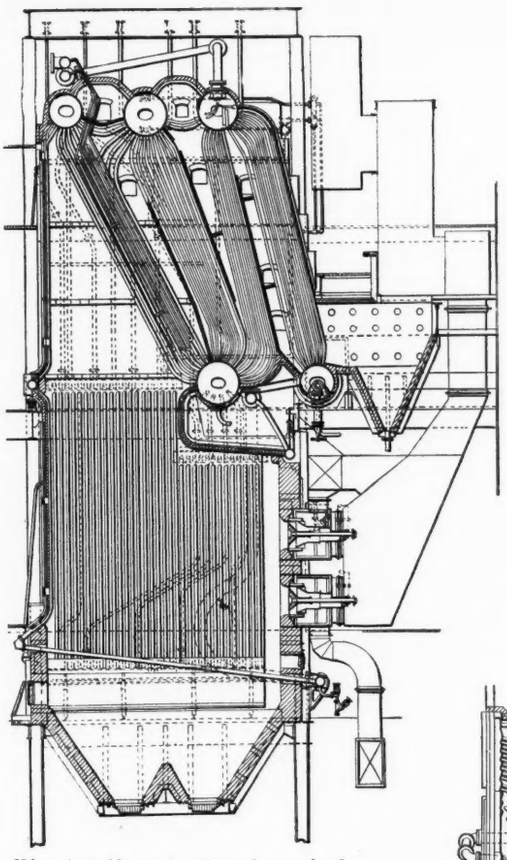


Fig. 6 (Above)—Semi-vertical Heine boiler having capacity of 200,000 lb. of steam per hour at 450 lb. pressure. This is installed at the Champion Fibre Company plant

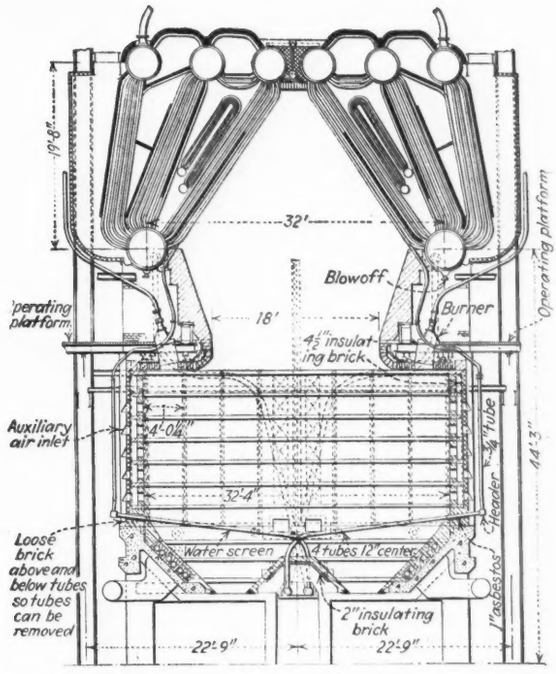


Fig. 9 (Above)—Double-set Stirling boiler having capacity of 254,000 lb. of steam per hour, 30,000 sq.ft. of heating surface and operating at 275 lb. pressure. Units of this type are installed at Trenton Channel and Avon

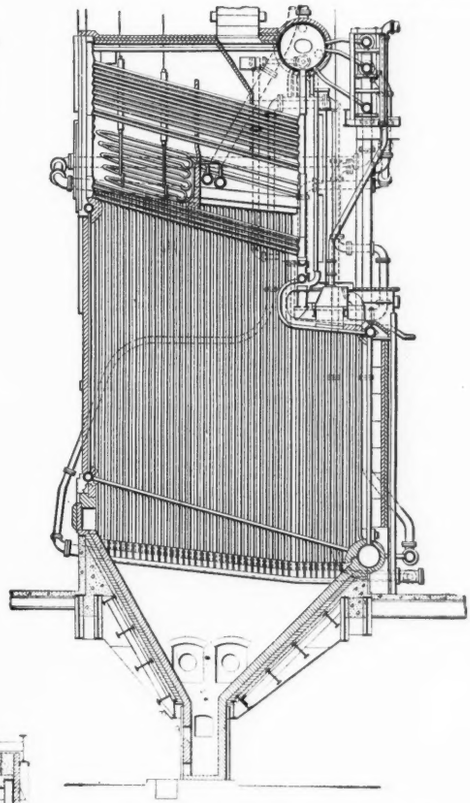


Fig. 8 (Above)—Springfield cast-steel sinuous header boiler of 245,000 lb. per hour capacity. This operates at 375 lb. pressure in one of the plants of the New York Edison Company

Fig. 10 (Below)—B & W type having capacity of 400,000 lb. per hour at 450 lb. pressure installed at Gould Street station in Baltimore

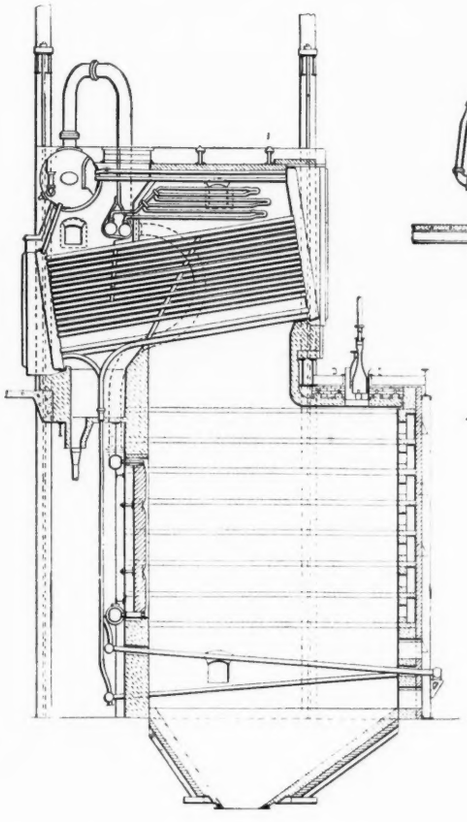
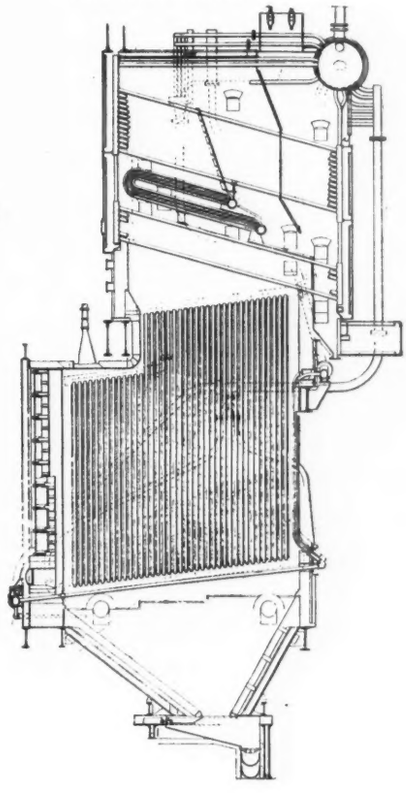


Fig. 7 (Left)—Heine horizontal boiler of 80,000 lb. capacity operating at 320 lb. at the Island Station of Northern States Power Company



temperatures can be secured, and, on account of the combination of radiant and convection heat, the steam temperature is very nearly constant at widely varying ratings.

Slagging is less likely to occur, because a tube temperature that produces slagging rarely extends the full length of the tube and such a temperature, if it does exist, is seldom continuous at any particular point for any great length of time.

The radiation losses are at a minimum, for the rear and front boiler walls are at a low temperature. Designs of this type are successfully operating with outputs of over 600,000 lb. of steam per hour for single units, and larger ones are in the course of construction. For outputs of 100,000 to 300,000 lb. of steam per hour, horizontal boilers, with or without economizers and air preheaters, and single-set vertical or semi-vertical boilers, with or without integral or separate economizers, offer good solutions.

For pressures of 800 lb. and above, there are successful installations of both the vertical, semi-vertical and horizontal types and more of both types are being installed. Inasmuch as the drums for these pressures must be forged, the horizontal boiler with only one drum is slightly less expensive for existing installations, but designs have been worked out for vertical and semi-vertical boilers that will overcome this difference in price.

Where water-cooled furnaces are to be used, it is usually less expensive to provide the necessary boiler connections with vertical or semi-vertical boilers, but otherwise there is little to choose between the two types for these high pressures. Some early comments were made to the effect that vertical or semi-vertical tubes could not be operated at as high ratings as the horizontal tubes, but this theory has been disproved in practice as vertical tubes have been operating at as high pressures and ratings as horizontal tubes for a period long enough to give results on which future operations can be predicted.

The last five years has seen rapid development in boiler design. This has not been radical but has followed well established practice, and results thus far obtained indicate that the designs have been carefully worked out and that the predicted results have been fully achieved. Future designs will probably be along the same general lines with outputs of single units running to a million pounds of steam or more.

Engineers in the Movies

An Al Jolson or a Charlie Chaplin can fill a movie show no matter if the building be a shack. But such genius cannot be found every day and the movie producer must offer more than a few thousand feet of inanity if the girl at the box office is to do much beyond finger-waving her tresses. That is why the refrigerating engineer has been called in to supply cooled air in summer and a tempered atmosphere in winter. What he did for the Howard Theater is told in next week's issue.

Trend in Central-Station Engineering

THE trend in engineering of steam central stations, as indicated in a survey of electric power by the Great Lakes Division of the National Electric Light Association, may be summarized as increased use of higher steam pressures and pulverized coal and an increase in the size of turbine generators and boiler units.

The increase in size of steam turbines has led to a greater use of compound machines, having two or three elements for the larger capacities.

Among the largest turbines now in service are:

1. A 65,000-kw., single-cylinder turbine at the Edgar Station near Boston.
2. A 91,500-kw., two-shaft, cross-compound turbine at the Crawford Avenue Station in Chicago.
3. A 94,000-kw., tandem-compound turbine at the Long Beach Station in Los Angeles.

Some of the large turbines on order or under construction are:

1. A 75,000-kw., single-cylinder turbine for Cahokia Station near East St. Louis, Illinois.
2. A 75,000-kw., single-cylinder turbine for the Huntley Station near Buffalo.
3. A 104,000-kw., two-shaft, cross-tandem-compound turbine for the Crawford Avenue Station at Chicago.
4. A 108,700-kw., two-shaft, cross-compound turbine for the Hudson Avenue Station at Brooklyn.
5. A 160,000-kw., tandem-compound turbine for the East River Station at New York.
6. A 160,000-kw., two-shaft, cross-compound turbine for the Hell Gate Station at New York.
7. A 165,000-kw., two-shaft, cross-compound turbine for the Hell Gate Station at New York.
8. A 165,000-kw., three-shaft, cross-compound turbine for the Philo Station near Zanesville, Ohio.

The largest turbine on record is the three-unit machine under construction for the State Line Station, in Indiana adjacent to Chicago, and rated at 208,000 kw. The high-pressure unit will be 76,000 kw. Each of the two low-pressure units will drive a main generator of 62,000 kw. and an auxiliary generator of 4,000 kw.

The increasing use of large-capacity steam boilers has been accompanied by new designs, in which the heating surfaces are rearranged rather than simply enlarged.

Two features of these new boiler designs are noteworthy. First, the use of water walls, or screens, exposed to the direct radiant heat of the furnace and consequently working at very high rates of heat absorption. Second, the use of air preheaters which receive the flue gas after it has passed the water-heating surface and absorb further heat by transfer to the combustion air on its way to the furnace.

The increasing use of higher steam pressures is evidenced by the increasing number of turbines and boilers designed for throttle pressures between 375 and 675 lb. It is also evidenced by the increased size of units constructed for 1,200 lb. steam pressure. Up to the present time, however, 1,200-lb. turbines have been operated as auxiliary units exhausting into the main station steam header.

The Deepwater Station, under construction near Wilmington, Delaware, has now on order two 54,000-kw. turbines of the cross-compound type, each of which is composed of one 12,500-kw. high-pressure element designed for 1,200 lb. throttle pressure, and one 41,500-kw. low-pressure element. This station is noteworthy in that all boilers will be constructed for 1,400 lb. pressure to deliver steam to the turbines at about 1,200 lb. pressure.

POWERGRAPHS

The Unusual in Power

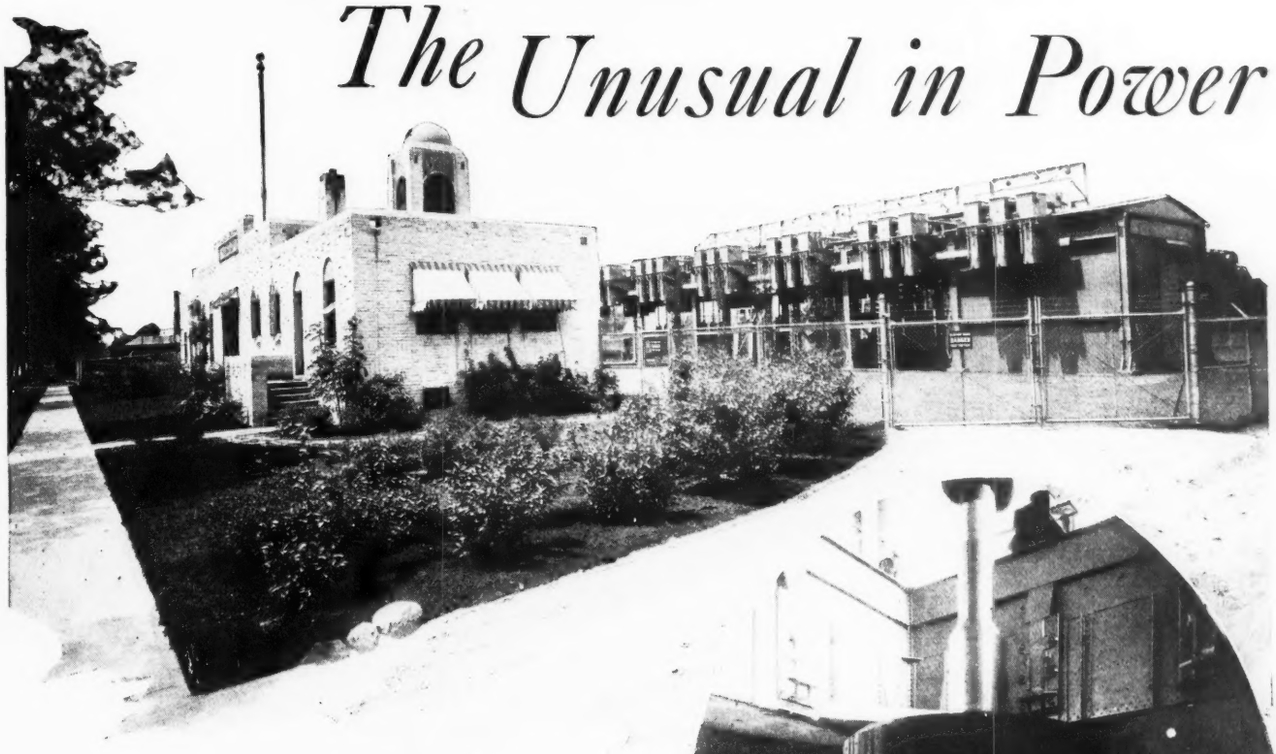
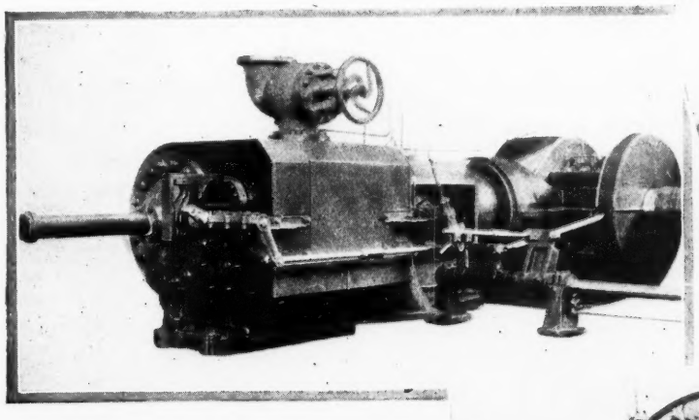


Fig. 1—An attractive substation in Wheaton, Ill.



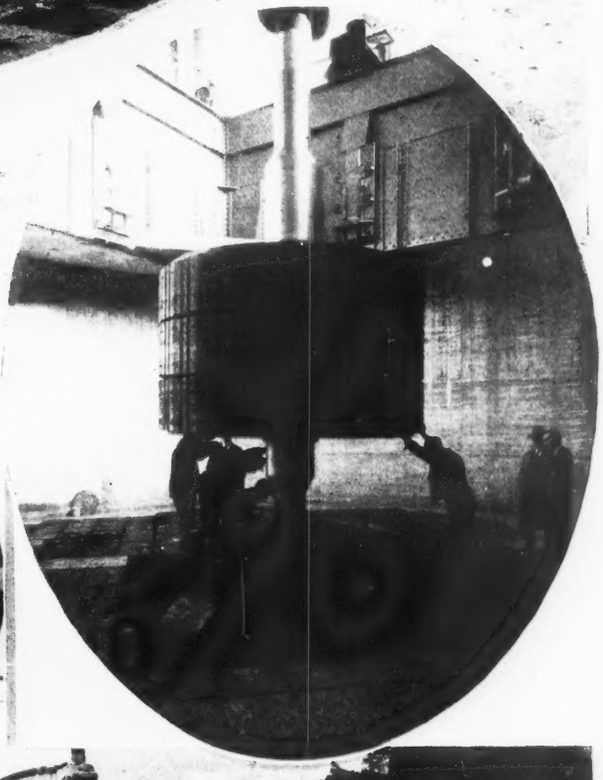


Fig. 2 (Above)—One side of a 2,000-hp. Fitchburg Prosser engine for a Hawaiian plant

Fig. 3 (Upper right)—A pit used by the General Electric Company to test out rotors for safe speeds

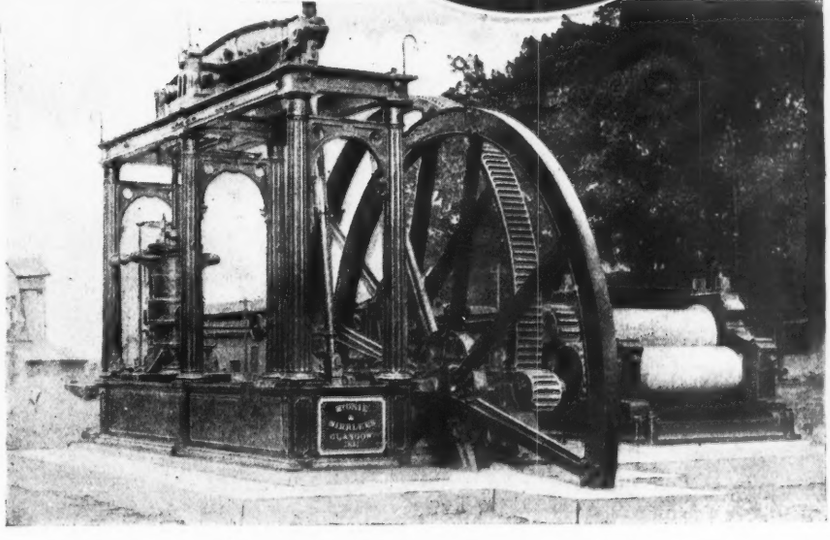


Fig. 4 (Right)—This engine, built by Mirrlees Watson Company, Ltd., Scotland, was installed in a Cuban sugar mill in 1851, ran for 63 years and is still in good condition

HIGH-SPEED CIRCUIT BREAKERS

Protect Rotary Converters

By R. E. Powers
General Engineer,
Westinghouse Electric & Manufacturing Company

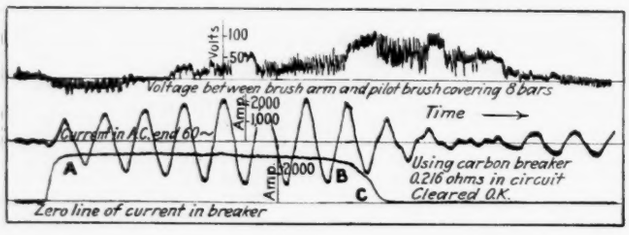
The behavior of synchronous converters during periods of direct-current faults is discussed and methods are suggested for protecting these machines against the objectionable effects of abnormal conditions

ON LARGE 60-cycle rotary converters, applied on systems of relatively stable voltage characteristics, through normal reactance transformers, approximately seven times full-load current will cause the converter to pull out of step or slip a pole if the load is not removed in a sufficiently short time. To protect a converter adequately from faults occurring in the direct-current system sufficient minimum short-circuit resistance must be provided in the direct-current circuit to prevent the current from approaching a pull-out value. If this is not done, a high-speed direct-current breaker must be used to relieve the converter of excessive load until the rotor can deliver up its stored energy and drop back in its phase position an amount sufficient to pass the required alternating current through its windings.

Fig. 1 shows the effect on the alternating and direct currents in a 500-kw. 60-cycle converter of the application of a severe overload, which was interrupted by an ordinary carbon breaker. From a study of the film it

* * * *

Fig. 1—Oscillograph record of alternating and direct currents in a 500-kw. rotary converter during the application and interruption of a heavy overload



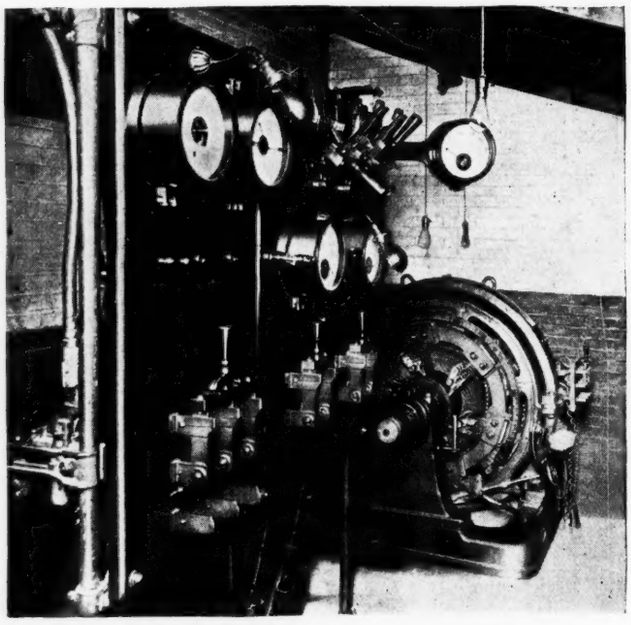


Fig. 2—Synchronous converter for supplying direct current to calender motors in a rubber mill

can be seen that the direct current reaches a maximum value at *A* in a fraction of a cycle, while the alternating current rises at a much slower rate and reaches its maximum in approximately five cycles, at which time the direct current has begun to decrease. The alternating current wave may be taken as a rough measure of the power input. This current rises at about one-half the rate of the direct current. During this period the difference between converter input and output is delivered from the stored energy in the revolving armature as it drops back in phase position an amount sufficient to pass the required current through its windings.

Fig. 1 shows that the alternating current reaches its maximum value five or six cycles after the overload, whereas, at that time the direct current has decreased slightly. The high rate at which energy is fed into the direct-current system produces rapid deceleration of the converter's armature, causing it to "overshoot" or pass through the angle necessary to deliver the required current. When the armature overshoots, excess energy must be supplied from the alternating-current system to restore the energy in the armature and advance it to a phase position that corresponds to the load conditions existing. The values of alternating current eventually exceed the corresponding values of direct current and reach a maximum at five to six cycles, indicating that the rotor has reached its maximum position at that period. This also indicates that the difference between input and output is effective in restoring the armature to its phase position corresponding to the existing-load conditions.

When the direct-current breaker opens at *B*, a high value of alternating current continues to flow in the converter windings to restore the armature to its no load position. At the instant of zero direct current at *C*, the power required to accelerate the rotor is approximately double the rated input of the unit. The alternating cur-

rent fluctuating with zero direct current gives definite evidence of armature overshooting or hunting. In about two cycles after the direct-current breaker opens, the armature passes through its no-load position.

The oscillogram, Fig. 1, was taken for an overload of approximately 200 per cent on a 500-kw. converter. Conditions would be considerably more severe for short circuits approaching or exceeding the pull-out value of the unit. However, the film shows the effect of the application and interruption of a heavy load on a 500-kw. unit.

Under conditions of steady power flow the net armature reaction in a converter is relatively small. The alternating and direct currents bear a constant relation to each other and can be considered to flow in opposite directions. The net armature reaction is the difference between the alternating- and direct-current reactions. When the ordinary direct-current breaker opens, with alternating current of overload magnitude flowing in the converter's winding, heavy uncompensated armature reactions exist that cause field distortion, excessive short-circuit current under the brushes, and high voltages between adjacent commutator bars. These result in severe sparking or flashing at the brushes.

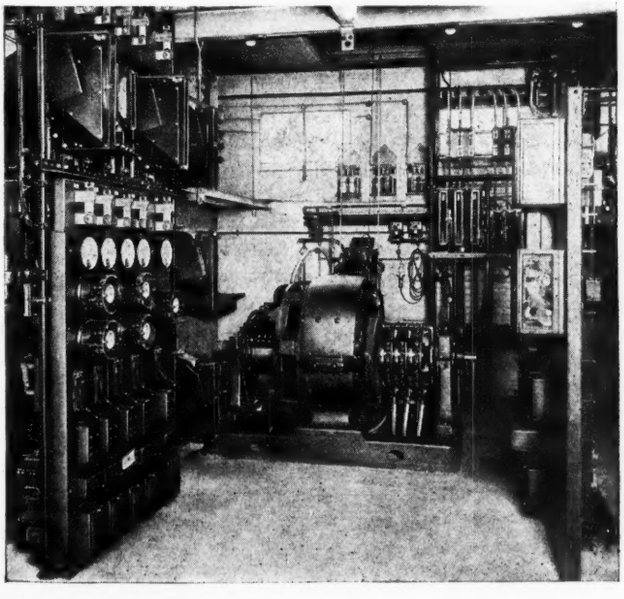
Development of the high-speed direct-current breaker provides a means of protecting synchronous converters from harmful effects of the direct-current system faults. A high-speed breaker is a contactor-type air-brake switch without auxiliary arcing tips. This breaker is designed to open its contacts in a period that will relieve the unit of excessive load before the rotor can drop back in phase position an amount sufficient to pass excessive alternating current through its windings. This prevents heavy unbalanced armature reactions and resultant flashing at the commutator.

It has been found that, generally, in 600-volt interurban, street-railway and mining service satisfactory over-all

* * * *

Fig. 3—A 500-kw. synchronous converter supplying power to a 600-volt system

The converter is protected from the effects of short circuits on the direct-current system by ordinary slow-speed breakers. The switching sequence is arranged so that fault current is dropped in two steps. The first breaker opens to insert a block of current-limiting resistance before the feeder breaker opens to isolate the fault.



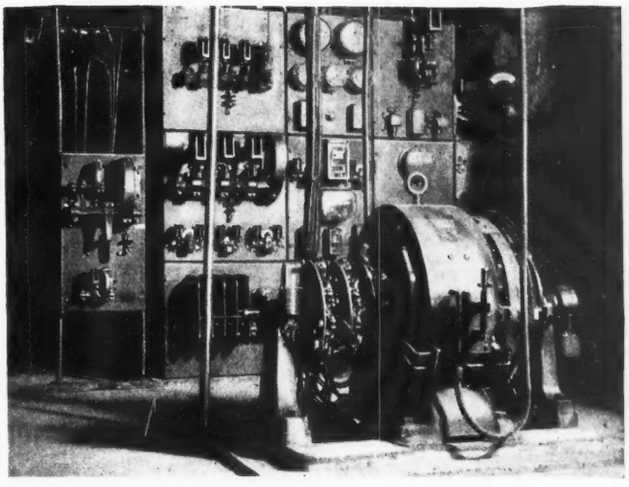


Fig. 4—Synchronous converter rated at 150 kw., 275 volts, supplying power to a coal mine

This machine is located under ground and is controlled by automatic switching equipment.

* * * *

performance of converters can be insured by providing a definite minimum value of short-circuit resistance in the direct-current feeder system. The maximum short-circuit current due to system faults is thus limited to a value that can be safely commutated during the period required for the breaker or contactor of normal speed to open. A common method of providing this resistance is to extend each feeder a sufficient distance from the substation before connecting to the trolley system. In cases where the trolley wire possesses sufficient conductivity, it may be desirable to use grid resistance rather than install a length of feeder copper, which would otherwise be unnecessary.

It is difficult, if not impossible, to specify a minimum resistance which, in conjunction with slow-speed breakers, will prove satisfactory on all systems. Any synchronous converter not provided with high-speed breaker protection will flash over on dead short circuit at or near its terminals. The minimum resistance of the feeder circuit to the first point connected to the trolley, or distribution system, should be as low as is consistent with satisfactory performance with the frequency and severity of shorts circuits encountered. Final determination of the proper value of resistance will often resolve into a cut-and-try method.

Recommended minimum values of positive-feeder resistance, not including the negative return circuit, for use with modern high-reluctance commutating-pole, 60-cycle, 600-volt converters, are given in the table. Motor-generators and 25-cycle converters will ordinarily perform satisfactorily with lower values of minimum resistance.

MINIMUM VALUES OF POSITIVE FEEDER RESISTANCE

Converter Capacity, Kilowatt	Feeder Resistance, Ohms
300	0.080
500	0.060
750	0.046
1,000	0.038
1,500	0.025
2,000	0.018
3,000	0.013

When providing the necessary resistance in feeders supplied by synchronous converters, the stability of the transmission line, the switching arrangement and load conditions must be given due consideration. The values as given in the table will limit the current, due to a short

circuit at the first feeder tap, to an amount that can be carried safely by the machine over the period of operation of a breaker of ordinary speed. However, if this current is totally interrupted by a single operation, the unit will in many cases flash over because of the subsequent lack of any commutating field, to neutralize the excessive alternating current which continues to flow in the windings.

Properly arranged switching equipments so designed that the converter is relieved of the short-circuit current in two steps, is effective in preventing flashing. A suitable time element is introduced in the tripping circuit of the feeder equipment so that the current is first reduced by the opening of an auxiliary breaker or contactor, which shunts current-limiting resistance. The opening of the feeder breaker then relieves the converter of the reduced current by the isolation of the fault. During the period between the opening of the first and second breakers a certain amount of direct current is present to neutralize the effect of the heavy alternating current in the windings to restore the armature to its proper phase position.

The presence of connected load on the station busbars provides a corrective effect of the same nature and, in multi-feeder stations operating at high load factor, may be sufficient. In manually operated stations where the proper switch sequence cannot be arranged, and where the load conditions do not afford sufficient protection, higher values of minimum resistance may have to be used in the feeder circuits to secure satisfactory results.

Some Causes of Trouble with Interpole Machines

By M. E. Wagner

On an interpole motor or generator commutation can be adversely affected by the strength of the interpole field. In many cases the strength of this field is too great for proper commutation and is adjusted to the correct value by connecting a shunt across the field winding terminals, as in the figure. One of the objections to this arrangement is, the resistance of the shunt and of interpole wind may change in service.

When the machine is new, the interpole strength may be correct to give sparkless commutation. Owing to loose, corroded or broken connections the resistance of either the shunt or the interpole-winding circuit may be changed. For example, a loose or corroded connection between two of the interpole coils would cause the resistance of the coil circuit to be increased. This would result in a larger portion of the total current flowing through the shunt and less through the interpole-field coils. A reduction of the current in the interpole winding for a given load on the machine causes the interpoles to be too weak and sparking will result.

On the other hand, if the resistance of the shunt is increased by poor connections, less current flows through the shunt and more through the interpole winding, for a given load on the machine. This will produce an interpole field too strong and the machine will spark at the brushes.

From the foregoing it is evident that, where a shunt is connected across the terminals of the interpole winding, it is possible for the strength of the interpole field to be changed by a variation in the resistance of the field-coil or shunt connections. For this reason it is essential that these connections be kept clean and tight. When an interpole machine develops sparking at the commutator, a check should be made on the interpole winding and its shunt connections. On account of the comparatively low resistance of the interpole winding and its shunt it does not require a very great change in the conditions of connections to affect adversely the machine's operation.

The effect of a change in strength of a motor's interpoles will be somewhat different from that for a generator. In both cases commutation will be affected, but in addition, on a motor a weak interpole field will cause a decrease in speed and on a generator an increase in voltage above that obtained with a proper value of inter-

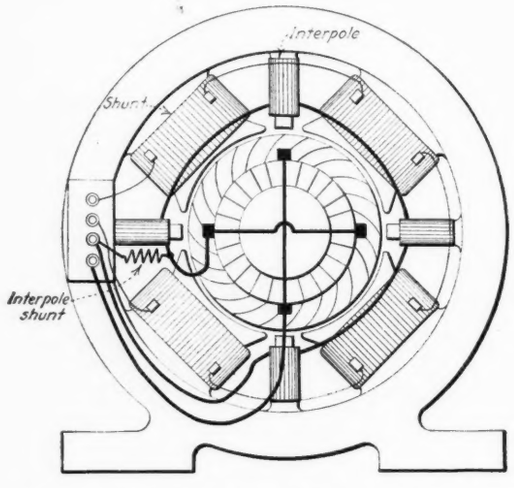


Diagram of shunt-type interpole direct-current machine

pole field. This is equivalent to shifting the brushes ahead of the neutral on a motor and backward on a generator.

If the interpole field is too strong, it will cause an increase in speed on a motor and a decrease in voltage on a generator below that obtaining with the interpole field of a value to give sparkless commutation. This action is similar to that obtained by shifting the brushes backward on a motor and forward on a generator.

The similarity between the effects of shifting the brushes on the commutator and the improper strength of the interpole field shows that brush shifting may be used to compensate for errors in the interpole-field strength. That is, if the interpole-field strength is excessive on a motor, shifting the brushes ahead of the neutral tends to improve commutation. On a generator the brushes would be shifted on the commutator back of the neutral.

The proper thing to do is to adjust the strength of the interpoles, first, by making sure that all the connections in the interpole-winding circuit are in good condition, and if this does not correct the fault, the strength of the poles can be changed by changing the resistance of the shunt or by changing the interpole air gap.

If there is no shunt on the machine, the strength of the interpoles can be changed by putting in or removing thin iron shims from between the interpoles and the yoke. Adding shims will bring the interpoles closer to the armature core and increase their strength. Removing shims from behind the poles will increase the air gap and decrease the interpole-field strength.

REVISED HEATING SYSTEM

Uses Less Fuel When Serving Double the Load

By W. A. Stiefel
Vice-president, Schering & Glatz, Inc.

PERHAPS the largest source of waste in many heating systems is the necessity of overheating certain parts of a building in order to keep the rest of it comfortable. Two years ago Schering & Glatz, Inc., installed in their Bloomfield, N. J., plant a zoned heating system, and the subsequent operation has demonstrated the importance of this source of heat waste.

The original plant erected in Bloomfield for the purpose of manufacturing certain of their pharmaceutical products is shown at *A* in Fig. 1, a plan of the present buildings. At this time a boiler house also was built which contained two 800-sq.ft. horizontal return-tubular boilers arranged for hand firing. Steam generated in these boilers at 75 lb. pressure was used in the ovens and kettles that formed part of the manufacturing process, and also for building heating. It was intended that only one boiler should be in regular service, leaving the second unit as a spare. Later, the building marked *B* was erected and steam for its heating system was obtained from the original boiler plant, and in 1926 building *C* was added.

In the first building there was installed 2,934 sq.ft. of direct radiation. When building *B* was erected, this was increased to 6,555 sq.ft. and the addition in 1926 made the total radiation connected to the original boiler plant 10,560 sq.ft. Thus, the load on the boilers during the winter months was increased to more than three times the design value. It was apparent that the addition of the heating load of building *C* would necessitate changes to the boiler plant in order for it to furnish sufficient steam for process and the increased building heating load.

A survey showed that the boiler capacity could be sufficiently increased by installing a new forced-draft fan, erecting a larger stack, installing new grates and making the ashpit tight.

Before going ahead with these changes, consideration was given to the possibility of improving the efficiency of the heating systems. It had been observed that during the majority of winter days the south side of the building was considerably warmer than the north. When sufficient heat was furnished to make the north side comfortably warm, the south side was uncomfortably hot and the occupants opened windows in order to cool off the rooms, thus wasting considerable heat. A difference of as much as 50 deg. has been recorded between the outside temperature on the north and south sides of the buildings.

In addition to the economy consideration it was desirable to improve the temperature control in certain of the departments where the manufactured products were sensitive to temperature conditions. These products became too hard to work when the temperature fell below 55 deg. F. and too soft at 70 deg. F.

It was finally decided to change the system to a remotely controlled zoned orifice heating system as recommended by the consulting engineers, Webster Tallmadge & Company, Inc.

The original heating system was a two-pipe vacuum system with globe valves and thermostatic traps at each radiator. Two vacuum pumps, one an electrically driven centrifugal pump with automatic starting equipment and the other a steam-driven reciprocating pump, delivered the heating system returns to a Cochrane open heater, where exhaust steam from the vacuum pump and a boiler-feed pump served to heat the water before going to the boilers.

Although hand fired with anthracite, the boilers are equipped with automatic damper regulation operated by the steam pressure and Campbell feed-water regulators. The damper regulators are arranged to hold the steam pressure between 75 and 70 lb. per sq.in. Process steam at 30 lb. pressure is supplied to building *A* through reducing valves.

In revamping the old system, Holly bushing orifices were installed in the inlet to all the radiators. The orifices are proportioned so that, when design pressure, three pounds in building *A* and one pound in the other buildings, is carried in the heating main, they will allow to flow into the radiators only the amount of steam the radiators can condense. If less than design pressure is maintained in the header, each radiator will receive only a portion of the steam it can condense, and it will be only partly heated. Thus, con-

> By zoning their heating system Schering & Glatz, Inc., made it possible to heat additions to their plant without increasing the steam-generating capacity, and in addition obtained over 40 per cent saving in fuel.

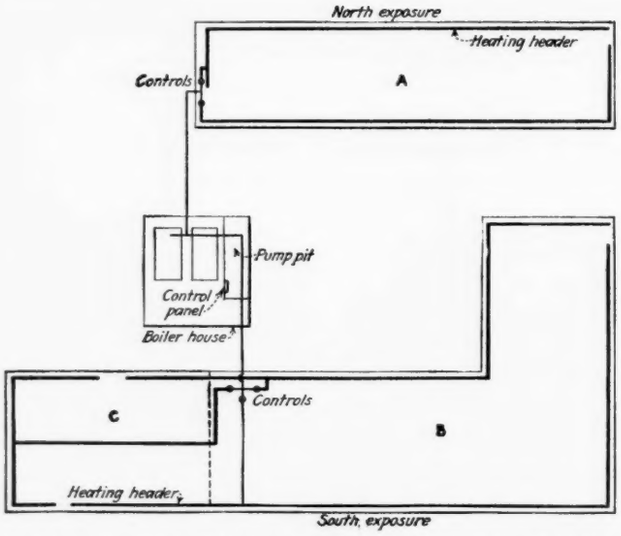


Fig. 1—Plan of buildings, showing heating system headers

trolling the steam pressure in the header affords a means of modulating the heat output of each radiator connected to it. The thermostatic traps were removed from the radiators in building *A*, largely because they were not operating properly, while those on the radiators in the other buildings were left intact.

Loop seals were provided wherever the drips from the risers join the header containing the radiator returns. This was necessary in order to prevent steam from entering the return lines. At the inlet to the return pump and in the basement of building *B* vents were installed, thus insuring atmospheric pressure in the return lines and providing an outlet for air during heating-up periods.

Steam is delivered to building *A* through a single main that rises to the top floor, where it divides into a north and south header. In the feed to each header is a remote control regulating valve. Likewise in building *B* a single main supplies steam through remote control valves to three headers. The arrangement of the main piping is shown in Fig. 1. Radiators are supplied through branch lines from the headers. With this arrangement the steam delivered to the north and south sides of each building may be separately adjusted to meet the heating demand.

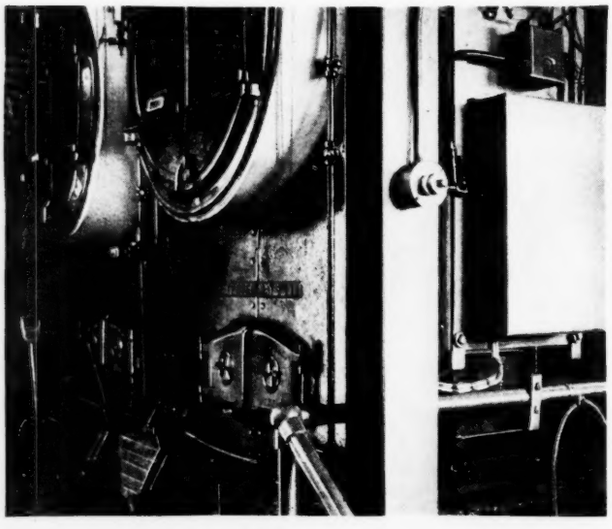


Fig. 2—The back of the control board may be seen at the right of the boilers

The control valves are essentially pressure regulating valves, arranged so that the pressure maintained in the headers may be varied to suit outside temperature conditions, from a control panel in the boiler room. The front of the panel is shown in Fig. 3. On it are mounted two long-distance indicating thermometers for indicating north and south outside temperatures, and five handles for electrically controlling the regulating valves. (A complete description of this equipment was published in the March 20, 1928, issue of *Power*.)

It was found that the revamped heating system produced such savings in steam required for heating that the two boilers without any alterations were able to heat

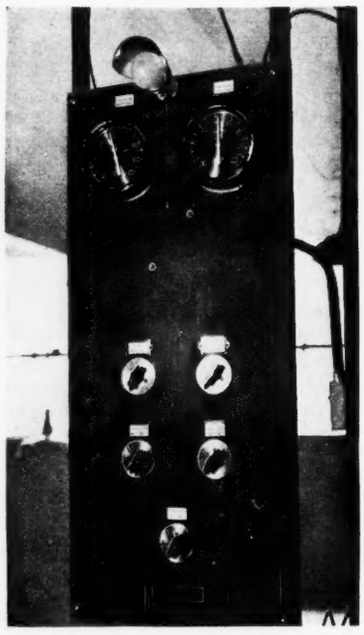


Fig. 3—Heating system control board

all the buildings during the coldest weather and at the same time supply whatever process steam was required.

The new system required little change in operating methods. Steam was turned on full in the morning until the buildings were heated to a comfortable working temperature. With this accomplished, the pressure maintained by the regulating valves was adjusted to suit the outside temperatures on the north and south exposures.

It has been found more convenient to operate the steam-driven return pump, since it delivers a more even flow of water to the heater than does the electric pump. The electric pump is started by a float switch which operates when the water in the receiver tank reaches a definite level. The pump then empties the tank and stops, thus producing an intermittent flow through the heater.

In addition to the foregoing the exhaust from the steam pump helps to heat the returns and the makeup before they are delivered to the boilers. Under average conditions the returns reach the boiler house at a temperature of about 100 deg. F., while during the coldest weather the return temperatures rise to between 120 and 130 deg. F.

No provision was made to meter separately the process and heating steam. For this reason it has not been possible to determine the exact saving obtained by the

installation of the zoned system of heating. That a saving has been made is unquestionable and can be seen from an investigation of the total coal consumption figures.

During the year 1925-26, when the buildings contained 6,555 sq.ft. of radiation, there was consumed 221 tons of coal, while in 1927-28, when supplying 10,560 sq.ft. of radiation, only 166 tons was consumed. The increased radiation would require, assuming the same rate of fuel consumption used before the changes were made, 356.5 tons of coal a year. Considered on this basis, there has been obtained a saving of $1,240 a year, with coal at $6.50 a ton. In considering these savings, it should be pointed out that the process steam consumption has been considered the same for the two years compared. While this of course is not a strictly accurate assumption, it is probably not far wrong as the amount of manufactured product has not varied greatly.

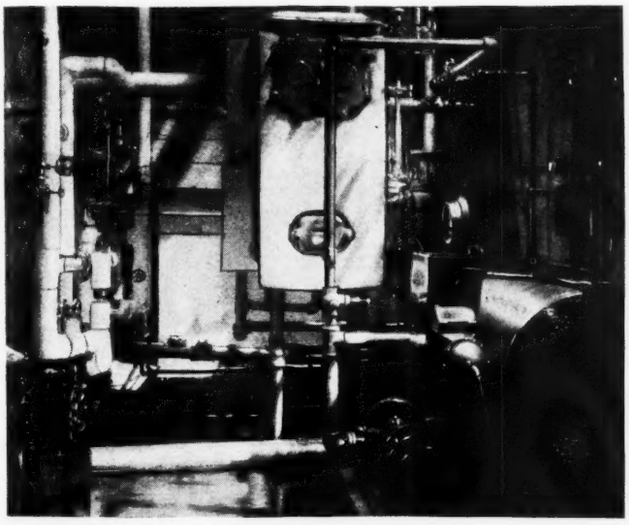


Fig. 4—Part of the steam pumps may be seen at the left side of the pump pit

Letters from an Oil Engine Operator

On the Use of Water Softeners

Dear Ed: So you are thinking of taking a job in a Western Diesel plant and would like to know about water softeners. It is a wonder you would not dig up some of this dope yourself once in a while.

All I know about it is that calcium and magnesium are mighty good insulators and interfere with the exchange of heat between the cylinders and the cooling water, and that 11 grains per gallon of temporary hardness is not uncommon. Assuming that about 8 gal. per hp.-hr. is the amount of water required by an oil engine and that the engine is 1,000 hp., then the total circulation would be 192,000 gal. each 24-hour day and in that water there would be some 324 lb. of sludge-forming substances. A precipitation of 25 per cent of this sludge would be a dangerous matter, and that amount is not uncommon, making an accumulation of more than a ton a month in the water jackets, a startling condition as you can see.

There are not many engineers who will believe this until they have actually tried to operate in some of the hard-water districts in the West. Generally speaking, it is of little use to attempt to handle a situation such as this at long distance, and the best method is to call upon some chemical firm working in the district in which the engines are installed.

To avoid scale formation, the water may be treated by chemical processes, some of which cause the scale-forming substances to separate from the water in the form of insoluble matter.

No doubt the lime-soda process is the most effective, for the water can be accurately and uniformly treated, adequate provision being made for removing sediment by settling and filtration.

This process has been improved in the last few years by the addition of sodium aluminate. This eliminates the three grams of hardness which the former treatment left and which under adverse conditions of rapid evaporation at the cooling pond or tower caused a concentration of the processed water, rendering the once processed water hard enough to form scale.

By using the lime-soda ash-soda aluminate treated water, an excess of sodium hydrate can be carried to prevent corrosion in the cooling system and maintain the water at zero hardness when there is danger of contamination with outside water, as for instance when makeup water is added.

A method by which a less intelligent operator may get very good results, not to insinuate that your intelligence is below par, my dear Ed, is what is known as the zeolite system. Zeolites are insoluble silicate materials containing soda which they exchange for the lime and magnesia in hard water. For example, if the hard water contains gypsum, the softened water will contain the same quantity of sodium sulphate, and sodium salts do not form scale.

My personal opinion is that if the sodium solution does no harm, it does no good other than to prevent scale formation. At any rate a given amount of this zeolite can take up only a definite amount of lime and magnesia, after which it becomes exhausted and is valueless until it is regenerated by means of passing common salt brine through the bed of zeolite. The sodium in the salt drives out the calcium and magnesium and replaces it with a fresh supply of sodium. Then the bed is washed free of the excess brine and it can be put to work again.

As I said at the start of this letter, I don't know much about this business, and you should get in touch with a chemical outfit who can advise you more intelligently. The main point is that these processes are less expensive than repairs to an engine. They are effective and easy enough to handle, but get in touch with some firm who knows local conditions; they will handle the situation best.

E. O. LESEID.

What Is Power?

What is power? Intangible, invisible, itself existent only in its effect upon finite things, it is yet the motive force which produces progress. Lacking progress, we stagnate, and die.

A Pioneer in High-Pressure Steam

By Geo. H. Gibson

There is nothing new about high steam pressures, for as early as 1897 De Laval built and operated boiler and turbine units at pressures close to the critical point

CARL GUSTAF PATRICK DE LAVAL

HIGH steam pressures and high temperatures are just now bringing about revolutionary changes in steam power plants. It may, therefore, be surprising to many steam engineers to be told that most of these so-called modern achievements were thought of and put into practice some thirty years ago.

Through the courtesy of the De Laval Steam Turbine Company in this country and in Sweden, the writer has been able to collect some highly interesting material concerning the famous Swedish engineer, De Laval, whose work was in many respects so accurate a prophecy that recent developments in high-pressure steam turbines constitute merely rediscovery. Although Benson and his boiler had not then been heard of, it is nevertheless true that in 1897 four 100-hp. turbines were operated with steam at 2,840 lb. pressure and 750 deg. F. temperature, and two 50-hp. turbines with steam at 1,420 lb. pressure. The complete power units, one of which is shown in an accompanying illustration, included each a turbine generator, a boiler with a feed pump and an air pump. They were built to supply power to the Stockholm Exhibition and ran throughout its duration, with entire success, except for occasional burning out of boiler tubes.

Carl Gustaf Patrick De Laval, to give his full name, was born in Blasenborg, Sweden, in the year 1845, and was the son of a captain in the Swedish army. He died in 1913. At the age of eighteen he entered the University of Upsala and afterward the Technical University at Stockholm, from which he was graduated in 1866. Upon leaving the University he was employed by the Stora Kopparberg Mining Company, but deeming his technical training insufficient, he returned to Upsala for special courses in physics and mathematics, receiving the degree of Doctor of Philosophy in 1872, after which he went back to the mining company and was sent to the Hartz district in Germany to study methods to be used in a plant to be erected at Falun for the production of sulphur.

In 1875 he joined the Kloster Iron Works, Germany, as mechanical engineer, and shortly afterward developed his first two inventions, one a device for the more perfect distribution of air in bessemer converters, and the other a crucible for galvanizing. Shortly afterward, while experimenting with centrifugal machinery, he hit upon the idea of the centrifugal cream separator, but as he could not persuade the management of the Kloster Iron Works to take up this invention, he returned to Stockholm in 1877, where he finally produced a commercially successful machine.

As early as 1870 he had made certain experiments on the application of steam nozzles in sand blasting, and in 1882 he constructed his first steam turbine, which was of the Hero reaction or Barker mill, type, and was used for driving a cream separator. This turbine used a large drop in pressure in one stage, and owing to imperfect expansion of the steam, the efficiency was low, but in 1888 De Laval conceived the idea of using diverging or flaring nozzles in which the steam could be expanded efficiently from the highest boiler pressure to the lowest exhaust pressure. This form of nozzle is now employed in practically all steam turbines, but when, in 1889, a United States patent was applied for, the Patent Office examiners did not believe the scheme workable, and it was only when the nozzle had been exhibited in actual operation at the Chicago World's Fair in 1893 that the office was convinced and issued a patent in 1894.

Having brought the steam turbine to a commercial success, De Laval sought for further improvements in economy through increased steam pressures and higher superheats. In order to eliminate danger of explosion

and the need for constant supervision of the plant, he designed a boiler of small water space, consisting of a single spiral tube. Having particularly in view the requirements of isolated plants and small central stations, five different sizes, of 5, 10, 30, 50 and 100 hp. capacity, respectively, were developed, of which altogether 31 units were built. Pressures of 1,400 to 2,800 lb. per sq.in. were carried, and six high-pressure units, two of 50 and four of 100 hp., furnished the electrical energy used at the Stockholm Exhibition, while two other units of 100 hp. each supplied for about a year all power required at the De Laval Steam Turbine Company's shops, at Jarla, Sweden. The date of starting the latter plant, March 9, 1897, undoubtedly marks the first time in history that power was supplied commercially by the use of steam at around 3,000 lb. pressure.

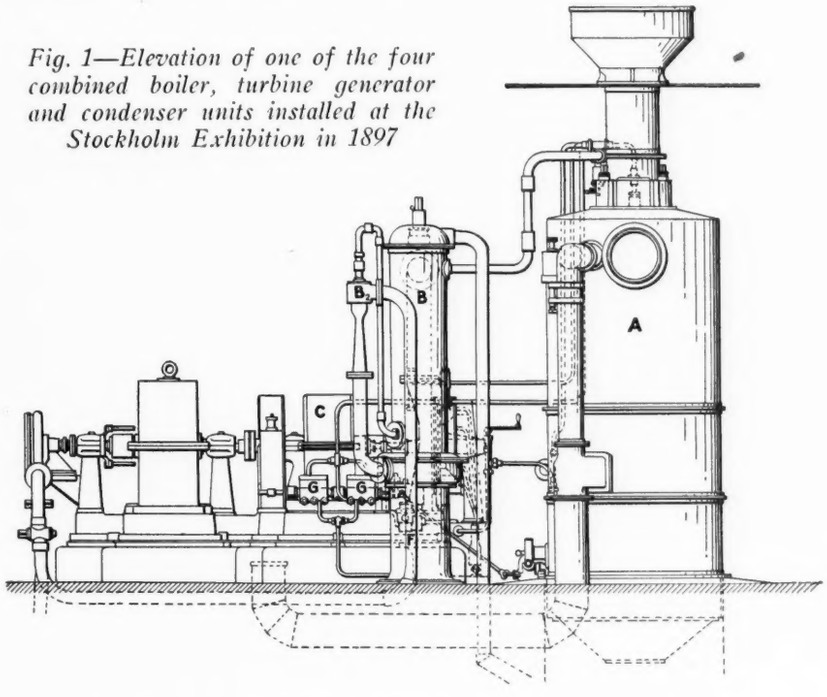


Fig. 1—Elevation of one of the four combined boiler, turbine generator and condenser units installed at the Stockholm Exhibition in 1897

The boiler *A*, Fig. 1, consisted of a spiral tube, which had been tested to 5,700 lb. per sq.in. The boilers were designed for a working pressure of 2,850 lb. per sq.in., but the log kept of the work mentions pressures of 3,100 and 3,420 lb., which is above the critical pressure for steam, and temperatures of 700 to 750 deg. F. Steel piping led the steam from the boiler to the governor valve and nozzles of the turbine.

The turbines were similar to those used for ordinary pressures. A pinion on the turbine shaft engaged two gears mounted on the shafts carrying the two armatures of a double direct-current generator. The turbine wheel carried two rows of buckets, with stationary guide vanes in between, or in other words, it had velocity staging, which had been developed by De Laval in 1889 in order better to utilize the high steam velocities resulting from high pressures. The governor was of the now widely used hydraulic relay type, throttling water under pressure from the feed pump to obtain a controlled pressure, which in turn operated the valves admitting steam to the turbine nozzles.

The surface condenser *B* received cooling water from the circulating pump, which was driven directly from the main turbine *C*. Air was exhausted by the ejector B_2. The removal pump *F* forced the condensate to a feed-water tank, whence it was fed to the boiler by the pump, the latter as well as the draft fan being driven from the main turbine.

The steam pressure was controlled automatically by a regulator which acted upon a blast gate in the air duct between the fan and the boiler. Provision was made for independent control of primary air beneath the grate and secondary air above the fuel bed. Coal was fed to the grates by gravity from a magazine. Upon rise of steam pressure, the gate throttled the air supply, while special air nozzles were provided for cooling in order to prevent the boiler from being overheated in the event of a sudden reduction in load. The air supply to the furnaces of De Laval's early high-pressure units was sometimes preheated by being carried around outside the boiler setting, perhaps the earliest application of cooling boiler-furnace walls by means of the furnace blast. These high-pressure boiler and turbine units, burning either bituminous coal or anthracite, could be started up very quickly. In the test logs the first readings under load occur within fifteen minutes after putting fire under the boiler.

The main turbines, auxiliaries and governing devices appear to have been entirely satisfactory, but difficulty was experienced with the boilers, the spiral tubes nearest the fire soon burning out. The resulting "explosions" were, however, harmless, owing to the small water content of the boilers and to the fact that the steam could escape only slowly. Examination of the tubes always showed a deposit of scale at the point of rupture, which explained the overheating and destruction.

The high-pressure boilers and turbines at the Stockholm Exposition were in service from the spring to the fall of 1897. After the Exposition it became difficult, owing to a business depression in Sweden, to obtain capital for further experimentation, and the work was tem-

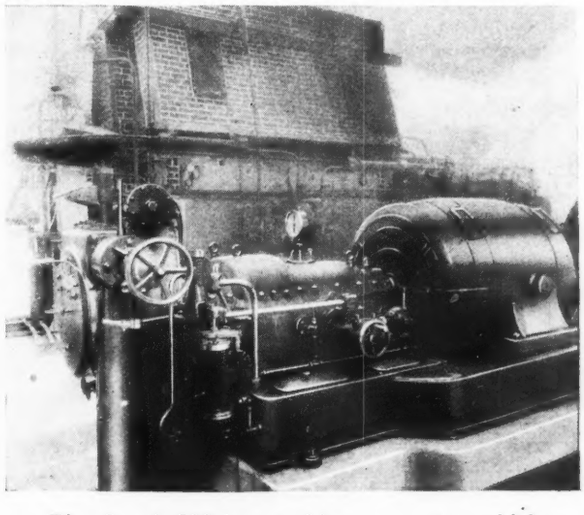


Fig. 2—A 500-kw. turbine generator which receives steam from an Atmos boiler at 1,420 lb. pressure

porarily abandoned. However, the Swedish De Laval Steam Turbine Company has subsequently put into operation the first modern high-pressure turbines. One of these, delivered in 1916 to the Carnegie Sugar Refinery, of Gothenburgh, Sweden, develops 600 brake horsepower, the turbine operating at a speed of 6,000 r.p.m., which is reduced by means of double helical gearing to 3,000 r.p.m. for the alternator. The four turbine wheels are overhung upon the pinion shaft, thus eliminating the high-pressure packing box and thereby greatly diminishing leakage. The turbine was originally intended to use steam at 710 lb., but the pressure has subsequently been increased to 1,420 lb. per sq.in. Steam is received from an Atmos boiler designed by one of De Laval's former assistants, J. V. Blomquist.

All De Laval's work was characterized both by radical changes from the then existing practice and by the highly successful adaptation of scientific principles directly to practical ends, without going through tedious step-by-step modifications. That De Laval's commercial achievements with steam turbines were not overwhelming in the manner of those of Parsons and others is probably due to the fact that his scene of action was a small country, out of the sweep of large business enterprise, as well as to the fact that he lived in a time not yet ready to comprehend and utilize the fruits of his creative genius.

Methods of Tempering Coal for Traveling-Grate Stokers

By L. W. Hayward
Combustion Engineering Corporation

MOST plant engineers who operate or have operated traveling-grate stokers agree that a decided improvement can be obtained in furnace conditions, if the coal is properly tempered before it passes under the gate. Not all coals are affected to the same degree by the addition of moisture. In the states where the traveling-grate stokers have their largest field, such as Indiana, Illinois and Iowa, the adding of moisture is very important if the best over-all efficiency is to be obtained. Plant engineers do not all agree as to its effectiveness, and this is undoubtedly due to the degree in which the moisture improves the burning quality of the different grades of fuel.

Everyone will agree, however, that it takes heat energy to dispose of this added moisture, as it has to be converted into steam, superheated and discharged up the stack. If 5 per cent by weight of moisture is added to every pound of fuel, from ½ to 1 per cent of the heat in the coal is required to evaporate this moisture. These heat units are a total loss, as they cannot be recovered, but the addition of this moisture often improves the burning quality of the coal to such an extent that a saving of from 2 to 10 per cent in furnace efficiency results. This improvement in efficiency is due to a reduction in ashpit loss and an increase in CO_2, which reduces the stack loss.

When coal is too dry, it tends to coke in bunches and the air passes up around these cakes of coke at the rear of the fire without passing through them, and the coke goes over into the ashpit unburned. This unburned coke is a direct loss as can be plainly seen, but the air that passes around the coke is equally as great a loss, as it increases the excess air required for combustion. When the coal is properly tempered, this condition is not found, as the coking tendency is greatly reduced and the fires burn off even and clean at the rear of the furnace. The moisture added to the coal reduces this caking tendency through the bursting action of the escaping steam.

The proper tempering of fuel is not easily accomplished, and this undoubtedly is the reason so many plants are burning dry coal. Unless the fuel is tempered evenly throughout and the moisture given a chance to soak into the interior of the lumps, it does more harm than good. Many plants attempt to wet coal in the stoker hopper by placing a sprinkler pipe over the hopper, but this is unsatisfactory as the water runs through in streaks, wetting the coal unevenly and only on the surface. Coal does not have an affinity for cold water, and this method should not be attempted.

Undoubtedly, one of the best ways to temper coal is to submerge it in water for a sufficient length of time to allow the moisture to soak through it thoroughly before conveying it to the bunkers and stoker hoppers. This method can be used only where a submerged storage system or submerged conveying system is available. Many plants temper their fuel while it is being conveyed to the bunkers, by a combination of sprinkling pipes over the traveling conveyors. This proves satisfactory if the conveying equipment is such that the water is thoroughly mixed with the coal before it drops into the bunker; although it is not as successful as the submerged method. Both systems have the disadvantage of conveying and placing in the bunkers coal that is wet, and if the sulphur content is high, the maintenance on the conveying and bunker equipment is increased and trouble is experienced with the coal hanging up in the bunkers. It has the advantage, however, that it greatly reduces the segregation of the fine and coarse particles during the conveying process, which helps to improve the burning quality of the fuel.

A substitution for the adding of water to coal is the use of exhaust steam in the stoker hoppers. By placing a perforated steam pipe in the hopper so that it is continually covered with fuel, the coal can be tempered very evenly. As coal has a greater affinity for steam than for water, the steam will enter the coal particles and thoroughly wet them before they pass under the gate. This method has proved satisfactory, although the problem of keeping the holes in the perforated pipe clean requires some attention.

When one considers all the advantages to be derived from proper tempering, it seems that more thought should be given to it in the designing of traveling-grate stoker plants and in the remodeling of old plants where bituminous coal is burned. The operating engineers are probably partly at fault in not insisting that some adequate method be incorporated in the design at the time the plant is built.

Proper tempering not only improves the burning quality of the fuel, but it helps greatly to prevent segregation of the fine and coarse coal, which is a very important item. It reduces the furnace draft required to burn a given quantity of fuel per square foot of grate surface on natural-draft installations and reduces the forced-draft air pressure required on forced-draft installations, thus making it possible to burn more coal per square foot of stoker installed. It also greatly reduces the siftings through the grate, which is another loss. When all these items are taken into consideration, the money required for the proper tempering of coal is easily justified.

Principles of Combustion

Some Fundamentals and Basic Formulas That the Engineer Should Keep in Mind

By A. A. Potter and H. L. Solberg

Dean of Engineering, Purdue University — *Ass't Prof. of Mech. Engineering, Purdue University*

THE combustible constituents of fuels which combine with oxygen to produce heat are carbon and hydrogen, and to a certain extent, sulphur. Sulphur, although of minor importance, is an undesirable impurity and is present in small quantities in most commercial fuels. These elements and the compounds of hydrogen and carbon, called hydrocarbons, combine under certain conditions and in definite proportions, with oxygen from the air to produce heat and light.

Requirements for Good Combustion

In order to secure good combustion, the following conditions must be fulfilled:

1. The combustible constituents of the fuel must be brought into intimate contact with sufficient oxygen to complete their combustion.
2. The temperature must be sufficiently high to support combustion.
3. Time must be available for the completion of the combustion reactions.

Element	Per Cent by Weight	Per Cent by Volume
Oxygen	23.15	20.91
Nitrogen	76.85	79.09

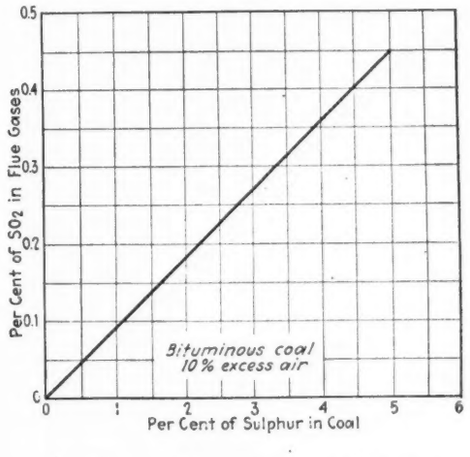
1 cu.ft. of O_2 + 3.78 cu.ft. of N_2 = 4.78 cu.ft. of air.
1 lb. of O_2 + 3.32 lb. of N_2 = 4.32 lb. of air.

Over three-fourths of the air, either by weight or by volume, is nitrogen, which is inert and does not enter into the combustion reactions. Therefore, a considerable quantity of heat is wasted in raising the temperature of the inert nitrogen to the discharge temperature of the waste gases. Although causing a serious heat loss, nitrogen serves one useful purpose, as the heat which it absorbs prevents the temperature of combustion from becoming so high as to be destructive to furnace refractories.

The importance of thorough mixing of oxygen and the combustible constituents cannot be over-emphasized. For complete combustion every molecule of combustible material must find its necessary quota of oxygen. Otherwise, the potential heat of the fuel will not be developed. Of necessity, these reactions must be completed in an atmosphere which consists of a small amount of free oxygen and a few molecules of combustible gas, together with the inert products of combustion and nitrogen. In most cases the nitrogen constitutes at least 80 per cent of the total gases present in the combustion chamber. Under conditions of good combustion, about 95 per cent of the gases in the upper part of a boiler furnace are inert nitrogen and dead products of combustion. It is in such an atmosphere as this that the combustion reactions must be completed if the loss due to incomplete combustion is to be minimized. Obviously, any means of increasing the turbulence and mixing of the gases will increase the chances that each molecule of combustible gas will find the oxygen necessary for its combustion.

Importance of Temperature

The second important requirement of good combustion is a temperature sufficiently high to support combustion. There is a definite temperature, called the ignition point,



Maximum percentages of SO_2 in dry products of combustion

below which gases will not burn. The ignition temperature of the more important elements and compounds is listed in Table I.

When a fresh charge of coal is placed on a grate, it is quickly heated by radiation from the brickwork and the hot fuel bed. The moisture is evaporated and the volatile is distilled as a series of complex hydrocarbon gases. The fixed carbon remains on the grate and burns by reacting with the air supplied through the fuel bed as soon as it is heated to the ignition temperature. Most of the volatile matter is distilled before the fixed carbon is heated to the ignition temperature, so that only the fixed carbon burns on the grate. The volatile matter, in the form of combustible gases, must be burned between the surface of the fuel and the point of entrance into the boiler tubes, otherwise secondary combustion results. The ignition temperature of these gases is between 1,000

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and 1,200 deg. F. If they come into contact with the relatively cold boiler tubes before combustion is complete, they will be cooled below the ignition temperature and cannot be burned no matter how much oxygen is present. The volatile matter may represent over half of the total heating value of the fuel in the case of high-volatile coals. Thorough mixing of these gases with oxygen and a temperature high enough to complete the combustion are essential if this heat is to be developed. It is for this reason that high-volatile coals require a large combustion chamber.

Time Element Important

The third requirement of good combustion is sufficient time for the completion of the reactions before the gases are cooled to a temperature below the ignition point. The time depends upon the nature of the fuel, the amount of oxygen and the turbulence. Combustible compounds of complex molecular structure do not burn as rapidly as those of simple structure.

Combustion Calculations

The chemical elements entering into combustion calculations are carbon (C), sulphur (S), hydrogen (H_2), oxygen (O_2) and nitrogen (N_2).

Avogadro's Law—Avagadro's Law is the basis upon which combustion calculations are made and may be stated as follows: "Equal volumes of all gases contain the same number of molecules when at the same pressure and temperature." Thus, at a standard temperature of 32 deg. F. and atmospheric pressure, one cubic foot of hydrogen contains the same number of molecules as one cubic foot of oxygen or carbon dioxide or nitrogen or any other gas. Since this same relation holds true at any other temperature and pressure, *the relative weights of equal volumes of all gases are in proportion to the relative weights of the individual molecules.* The molecular weights of the important elements and compounds are shown in Table II. The molecular weights of hydrogen and oxygen are 2 and 32 respectively. Consequently, at any given temperature and pressure, 2 lb. of hydrogen and 32 lb. of oxygen occupy equal volumes.

TABLE I—HEATING VALUE AND IGNITION TEMPERATURES OF IMPORTANT COMBUSTIBLE ELEMENTS AND COMPOUNDS

Substance	Chemical Symbol	Heating Value B.t.u. per Lb. Higher	Heating Value B.t.u. per Lb. Lower	Higher Heating Value, B.t.u. per Cu.Ft. at 32 Deg. F. and 760 mm.	Ignition Temperature Deg F.
Hydrogen	H_2	62,000	52,920	348	1,130
Carbon to CO	C	4,380	.....	....	760–925*
Carbon to CO_2	C	14,540	.....	....	760–945*
Carbon monoxide	CO	4,380	.....	342	1,210
Sulphur to SO_2	S	4,050	.....	....	470
Sulphur to SO_3	S	5,940	.....	....	470
Methane	CH_4	23,850	21,670	1,073	1,202
Ethane	C_2H_6	22,230	20,500	1,883	1,000
Ethylene	C_2H_4	21,450	20,420	1,675	1,022
Acetylene	C_2H_2	21,460	21,020	1,590	900

*The ignition temperature of fixed carbon varies with the kind of coal and is highest in coals containing the greatest amount of fixed carbon, such as anthracite.

Data from "American Fuels," Bacon and Hamor.

The Mol—Certain combustion calculations can be simplified by the use of a unit called the "mol." The mol may be defined as a quantity of an element or compound equal in weight to the molecular weight of the element or compounds. Thus, one mol of O_2 weighs 32 lb., one mol of H_2 weighs 2 lb., one mol of N_2 weighs 28 lb., and one mol of any gas weighs m pounds, where m is the molecular weight of that gas. Since at any given pressure and temperature, there are the same number of molecules in 32 lb. of O_2, 2 lb. of H_2 or m lb. of any gas, *the volume occupied by one mol of each of these gases is the same.*

TABLE II—ESSENTIAL PROPERTIES OF IMPORTANT ELEMENTS AND COMPOUNDS ENTERING INTO COMBUSTION CALCULATIONS

Substance	Chemical Symbol	Molecular Weight Exact	Molecular Weight Approximate	Specific Volume at 32 deg. F. and 760 mm.	Mean Specific Heat 0–600 Deg. F
Carbon	C	12.005*	12*	.....	.....
Hydrogen	H_2	2.015	2	177.936	3.475
Sulphur	S	32.07*	32*	.....	.....
Oxygen	O_2	32.00	32	11.209	0.2211
Nitrogen	N_2	28.02	28	12.809	0.2406
Air	....	28.94	28.95	12.390	0.2484
Carbon dioxide	CO_2	44.01	44	8.103	0.2214
Carbon monoxide	CO	28.01	28	12.811	0.2406
Water vapor	H_2O	18.02	18	.....	0.4586
Sulphur dioxide	SO_2	64.07	64	5.473	0.1544†
Methane	CH_4	16.03	16	22.222	0.649
Ethane	C_2H_6	30.05	30	11.805	.....
Ethylene	C_2H_4	28.03	28	12.807	0.461
Acetylene	C_2H_2	26.03	26	13.468	.....

*Atomic weights of carbon and sulphur. The molecular weights of these solids depend upon their form and are not definitely known.

†Specific heat 0–60 deg. F.

Data from Bacon and Hamor—"American Fuels."

Let V = the volume of one mol of any gas.
v = the specific volume or volume of one pound of any gas.
m = the molecular weight of the gas.
Then $V = mv$.

At any pressure and temperature V is the same for all gases and is a constant. Using the data for oxygen from Table II, $V = 32 \times 11.209 = 358.7$ cu.ft. at 32 deg. F., and 760 mm. of mercury. The value of V may be calculated for any temperature by using the general gas equation:

$$\frac{pv}{T} = \frac{1{,}544}{m} \text{ or } V = 1{,}544\ \frac{T}{p}$$

where T = absolute temperature in deg. F. and p = absolute pressure in pounds per square foot. A mol may therefore be defined as: (1) 358.7 cu.ft. of any gas at 32 deg. F. and 760 mm. of mercury, or (2) a quantity of matter having a weight equal to the molecular weight of the element or compound.

Molal relationships are also volume relationships. If a gas is reported as composed of 21 per cent oxygen and 79 per cent nitrogen by volume, this analysis may also be interpreted to mean that 100 mols of the gas are composed of 21 mols of oxygen and 79 mols of nitrogen. This relationship is convenient in converting a volumetric analysis of a gas to a gravimetric basis.

Combustion of Elementary Fuels

The important combustible constituents of fuel are carbon, hydrogen, sulphur and the compounds of hydrogen and carbon, called hydrocarbons. The hydrocarbon compounds may exist in many different forms and may undergo partial combustion or thermal decomposition to form many other compounds. The oxygen required for the combustion of these hydrocarbons depends upon the relative weights of hydrogen and carbon present, and this can be determined by an ultimate analysis of the fuel without any regard to the molecular structure. The heating value of the hydrocarbons depends upon their molecular structure, but this can be determined by a calorimeter.

When oxygen is passed over incandescent carbon, the resulting products of combustion are either carbon dioxide (CO_2) or carbon monoxide (CO). The final results may be expressed as follows:

$$C + O_2 = CO_2 + 14{,}540 \text{ B.t.u. per lb of carbon burned.} \quad (2)$$

$$2C + O_2 = 2CO + 4{,}380 \text{ B.t.u. per lb. of carbon burned.} \quad (3)$$

Equation (2) represents the complete combustion of carbon with the development of the entire heating value of the fuel. Reaction (3) is due to incomplete combustion, with the development of only about 35 per cent of the heating value. The combustion of the CO formed by reaction (3) can be completed according to the following:

$$2CO + O_2 = 2CO_2 + 10{,}160 \text{ B.t.u. per lb. of carbon burned.} \quad (4)$$

The quantity of heat generated is the same whether the carbon is burned to CO_2 directly or to CO and then to CO_2. However, the escape of a small amount of CO in the products of combustion results in the loss of an appreciable amount of undeveloped heat.

When air is passed through the fuel bed on a grate or stoker, reaction (2) predominates in the lower three to five inches of the incandescent fuel bed. Practically all the free oxygen is combined with carbon in this zone to form CO_2, so that little oxygen remains at a short distance above the grate. At high fuel bed temperatures (2,000 to 2,500 deg. F.) and in the absence of oxygen, the CO_2 is reduced to CO according to the following:

$$CO_2 + C = 2CO \quad (5)$$

This reaction is accompanied by the absorption of heat from the fuel bed. If sufficient air is supplied above the surface of the fuel bed to burn this CO to CO_2, the full heating value of the fuel will be developed.

Complete combustion of carbon, represented by the reaction $C + O_2 = CO_2$, can be interpreted to mean:

1 molecule of carbon + 1 molecule of oxygen produce 1 molecule of carbon dioxide.

1 mol of carbon + 1 mol of oxygen produce 1 mol of carbon dioxide. Since the molecular weights of carbon, oxygen and carbon dioxide are 12, 32 and 44

12 lb. of carbon + 32 lb. of oxygen produce 44 lb. of carbon dioxide, or

1 lb. of carbon + 2.667 lb. of oxygen produce 3.667 lb. of carbon dioxide. As the oxygen is obtained from the air which is 23.15 per cent oxygen by weight, the preceding statement can be written as follows:

1 lb. of carbon + 11.52 lb. of air produce 3.667 lb. of carbon dioxide + 8.85 lb. of nitrogen.

The incomplete combustion of carbon is represented by

$$2C + O_2 = 2CO$$

24 lb. of carbon + 32 lb. of oxygen produce 56 lb. of carbon monoxide.

1 lb. of carbon + 1.333 lb. of oxygen produce 2.333 lb. of carbon monoxide, or

1 lb. of carbon + 5.76 lb. of air produce 2.333 lb. of carbon monoxide + 4.43 lb. of nitrogen.

Combustion of Hydrogen—Hydrogen is one of the most important combustible constituents of fuels because of its high heating value, 62,000 B.t.u. per lb. It is easily burned and unites with oxygen to form vapor:

$$2H_2 + O_2 = 2H_2O + 62{,}000 \text{ B.t.u. per lb. of hydrogen burned.} \quad (6)$$

Or 2 mols of hydrogen + 1 mol of oxygen produce 2 mols of water vapor.

2 cu.ft. of H_2 + 1 cu.ft. of O_2 produce 2 cu.ft. of H_2O.

1 cu.ft. of H_2 + 2.39 cu.ft. of air produce 1 cu.ft. of H_2O + 1.89 cu.ft. of nitrogen.

Also 4 lb. of H_2 + 32 lb. O_2 = 36 lb. H_2O.

1 lb. of H_2 + 34.5 lb. of air produce 9 lb. of H_2O + 26.5 lb. of N_2.

It is to be noted that the hydrogen which is combustible is not the total hydrogen of the fuel, but the so-called net or available hydrogen. It is assumed that all the oxygen of the fuel is combined with hydrogen in the form of free or combined water, thereby rendering a portion of the hydrogen inert. Although this assumption is not strictly correct, especially for the low-grade, high-oxygen coals, it is sufficiently accurate for practical purposes. The available hydrogen H_a can be calculated:

$$H_a = H - \frac{8}{0} \quad (7)$$

where H is the total hydrogen content in the fuel, from the ultimate analysis and 0 is the total oxygen content of the fuel from the ultimate analysis. Thus, if a fuel contains 5 per cent of hydrogen and 16 per cent of oxygen, the available hydrogen equals $\left(0.05 - \frac{0.16}{8}\right)$ of 0.03 lb. per lb. of fuel.

Combustion of Sulphur—The combustion of sulphur ordinarily takes place according to the following reaction:

$$S + O_2 = SO_2 + 4{,}050 \text{ B.t.u. per lb. of sulphur burned.} \quad (8)$$

or 1 mol of S_2 + 1 mol of O_2 = 1 mol SO_2.

32 lb. of S_2 + 32 lb. of O_2 = 64 lb. SO_2.

1 lb. of S + 1 lb. of O_2 = 2 lb. SO_2.

1 lb. of S + 4.32 lb. of air produce 2 lb. of SO_2 + 3.32 lb. of N_2.

The sulphur content of even the poorest of fuels is rarely over 5 per cent and is often under 1 per cent. The refuse left from the combustion of coal ordinarily contains some sulphur so that only a part of the sulphur content of the fuel is discharged with the products of combustion. The curve shows the percentage of SO_2 in the products of combustion of average bituminous coal with varying amounts of sulphur when burned with only 10 per cent excess air. Only in exceptional cases will the products of combustion contain as much as 0.4 per cent of SO_2. This curve is based on the assumption that all of the sulphur in the coal appears in the products of combustion, which is not the case with most coal. The error is small, however.

Combustion of the Hydrocarbons—Several hundred different hydrocarbon compounds are known to exist in fuels, having the general chemical formula, $C_nH_{2n} \pm y$, where $y = 2, 0, -2, -6, -12$, etc. Petroleum and the volatile matter of coal are composed of such compounds.

When heated to the ignition temperature, these compounds vary from light gases to heavy tars. The heavier compounds are unstable at high temperatures and may undergo partial combustion and thermal decomposition or cracking to form new compounds.

TABLE III—COMBUSTION DATA, IN POUNDS PER POUND OF COMBUSTIBLE SUBSTANCE

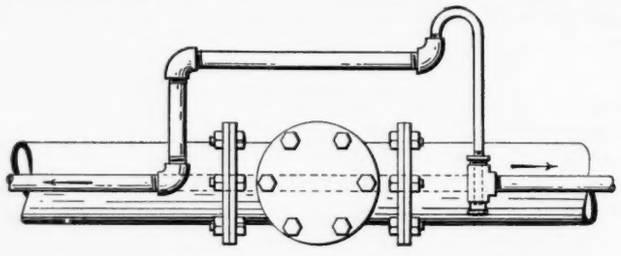
Constituent	Reaction	Requirements for Perfect Combustion: Oxygen	Air	Products of Perfect Combustion, Lb. per Lb. of Combustible: CO_2	CO	H_2O	SO_2	N_2
Carbon	$C+O_2=CO_2$	2.667	11.52	3.667	.....	.....	.....	8.85
Carbon	$2C+O_2=2CO$	1.333	5.76	.....	2.333	.....	.....	4.43
CO	$2CO+O_2=2CO_2$	0.571	2.46	1.571	.....	.....	.....	1.89
Hydrogen	$2H_2+O_2=2H_2O$	8.000	34.56	.....	.....	9.000	.....	26.56
Sulphur	$S+O_2=SO_2$	1.000	4.32	.....	.....	.....	2.000	3.32

Right Out of the Plant

BOILED-DOWN EXPERIENCE PASSED ALONG TO THOSE WHO MUST SAVE MONEY, IMPROVE THE PRODUCT AND KEEP THE PLANT RUNNING

Raising an Air Line on Vacuum Heating System

WHEN steam connections for heating our new building were called for, we found a tee in place in the tunnel, but the vacuum pipe ran squarely across the opening. This was taken care of as shown in the accompanying drawing, the dotted lines indicating where



Change made in air line

the pipe was found and the full lines showing where we placed it.

This method was used so that the pipe would be kept drained of water at all points. Considerable water is carried by the air lines, and wherever the water collects corrosion starts. The direction of flow of both steam and air lines are indicated by the arrows.

Elgin, Ill. W. L. PARKER.

Electrical Defects Cause Generators to Vibrate

VIBRATION in turbine alternators may be caused by electrical faults upsetting the magnetic balance of the windings. These faults are short circuits and grounds in the rotor coils or an unequal air gap when the bearings are worn. The following are instances of vibration from these causes:

Vibration occurred in a turbine alternator but this disappeared when the field coils were not excited and was most serious when the coils were alive. The turbine casing was opened, but no fault could be found at the steam end. As it appeared unlikely that the static balance was at fault, an inspection was made of the rotor windings, which showed the insulation resistance to be low. Some of the coils were found to be loose and on all the insulation was deteriorated by age and excessive temperatures. All the coils were rewound and when this was done the machine ran without vibration. The bad condition of the insulation permitted current leaks that upset the magnetic balance.

In another instance an alternator was running satisfactorily when it suddenly began to vibrate. This was so serious that the emergency trip on the governor was opened by the attendant, when the machine stopped so suddenly that stripping of the turbine blades was suspected. An insulation test showed a dead ground in the rotor. This part of the unit was removed and replaced by a spare. When the machine was put into operation again, the vibration had disappeared. An examination of the rotor coils showed that a hole had been worn in one of the micanite slot liners, allowing the coil to come in contact with the core. This fault, along with defects in two other coils, made it necessary to rewind the rotor partly. The vibration was caused by magnetic unbalance, and the quick stopping of the unit was due to the damping effect of the short circuit present in the windings.

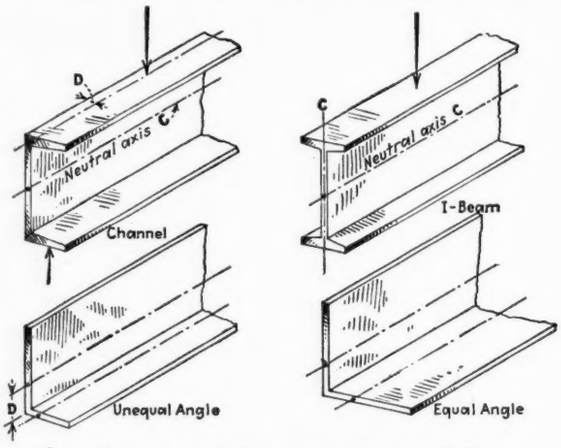
Vibration caused by magnetic unbalance can, of course, be detected by running the unit up to speed when the field coils are dead. If the fault is electrical, the vibration will be absent, but will be present as soon as the exciting current is applied. Electrical faults in the stator winding will also cause magnetic unbalance and vibration. It is therefore important that the insulation on the winding be kept in good condition.

Brentford, England. W. E. WARNER.

How to Drill Structural Steel Beams

THE principal shapes of structural steel in common use are the channel, the I-beam and the angle. Each of these shapes is rolled in dozens of sizes and weights. The steel used in their manufacture is low carbon, and is not difficult to machine.

Drilling is the principal machining operation on structural shapes. Although welding is coming into use, the



Location of neutral axes in structural shapes

leading method of attaching connecting pieces is by rivets and bolts put through holes that are drilled or punched.

Although making holes is about the simplest operation imaginable, a large majority of machinists and other mechanics who have this to do and are not given a definite layout, do not know how to space these holes to best advantage. The great advantage of structural steel is its lightness for a given strength. This strength, however, may be greatly reduced by drilling holes unintelligently.

For every given cross-section there are two "neutral axes" generally recognized. These are at right angles to each other. The neutral axis in consideration is the one at right angles to the direction of the load, or pressure. In the drawing of the channel, for example, the axis marked *C* is the one to consider when the channel is standing on its edge and the load is downward.

Extending throughout the length of a piece, the neutral axis becomes a neutral plane, but common usage speaks of it as an "axis." Material at the neutral axis, and near it, has no practical value in supporting loads.

Thus, whenever possible, holes should be made on the neutral axis, for there they do not weaken the piece On the contrary, however, holes made some distance away weaken the steel considerably, and those at the extreme distance are dangerous in highly stressed pieces.

The drawings show the three familiar shapes with the neutral axis marked on each in both directions. Both angles of equal and unequal legs are shown, because the position is rather different.

Some neutral axes are at the center of a section or at the center of gravity. Those marked *C* are that way.

One axis of a channel is central at *C*, and the other is at a distance *D* away from the back. This distance varies with each size, but making *D* equal to one-fourth the width of the flange is quite close.

On angles with unequal legs the neutral axis laid out on the long leg is marked *D* also. This distance is approximately one-third of the width of this long leg. The other neutral axis is about one-fourth the width of its leg, as measured from the corner over. On angles of equal legs the neutral axis is away from the corner about three-tenths the width of the leg.

Holes may be drilled along the neutral axis with perfect confidence. Knowing where this axis lies, the mechanic can proceed more safely. An examination of broken automobile frames, for instance, will invariably show that breaks come from violation of this law.

Middletown, N. Y. DONALD A. HAMPSON.

Reducing the Cost for Water in the Ice Plant

WE HAVE two 7x7-in. twin-cylinder, vertical-type ice machines with water jackets. As we have no cooling tower, we use city water for cooling, and this water was wasted to the sewer until we made some changes in the system.

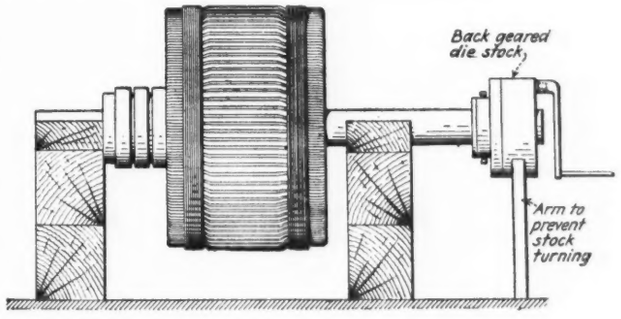
The discharge line from the jackets was run to a 50-gal. tank in the boiler room that has been in the plant for a couple of years and never used. This tank was connected by a $\frac{3}{4}$-in. line to our feed-water heater, and this allowed us to use this jacket water, which was formerly wasted, as makeup feed for the boilers.

We also made a change in the cooling system for the ammonia condenser. The cooling water was taken from the house tanks, on the roof (elevation 150-ft.). The water is supplied to these tanks by a centrifugal pump, belt driven from the motor that drives the ice machines. In the summer months this water was used over and over again, without a chance for cooling, and when it became too warm for use in the condenser, it was necessary to use water direct from the city main, and waste it to the sewer. To eliminate this waste we made a 2-in. connection from the soft-water side of the water softeners, to the city water connection at the ammonia condenser. The softened water is first passed through the condensers, then through the pump to the roof tanks. If more water is drawn from the tanks than is being passed through the condenser, the main house pumps cut in and supply the difference. In this way we are able to save the cost of the water that used to be wasted, also the cost of the electric power for pumping the makeup water to the roof tanks with the house pumps.

Los Angeles, Calif. LAWRENCE B. BROWN.

Method of Banding a Large Rotor Without a Lathe

SOME time ago I had a large rotor to band with No. 12 banding wire, which required considerable tension. The job was accomplished in the following manner: A back-geared die stock was clamped to the rotor shaft by means of a dummy die longer than the others and made to engage in the keyseat. A piece of $\frac{1}{16}$-in. fiber was placed around the shaft to prevent the teeth of the dies from marring it. The follower portion of the die head



Rotor was turned with a back-geared die stock

was prevented from turning by means of a torque arm fastened to it. The sketch shows plainly the set-up.

The die stock afforded a ratio of about eight to one. In place of the usual handle a 20-in. crank was used and the rotor banded quite easily. W. L. STEVENS.

New Westminster, B. C., Canada.

Slamming Air-Compressor Valves

WE HAD moved our air compressor and receiving tank a considerable distance from their old locations, and in the new setting there was not room for the receiving tank in the same building with the compressor. It was therefore placed in a building about 45 ft. distant and connected by underground piping. When the compressor was started, the valves slammed badly owing to excessive air-pressure pulsations in the pipe. These pulsations increased with the length of the pipe between compressor and receiver and also with the rotative speed of the compressor. Our compressor was overloaded and ran beyond its rated speed.

To reduce the intensity of the pulsations we obtained a piece of 14-in. pipe about $4\frac{1}{2}$ ft. long and threaded and capped it at both ends. The caps were tapped eccentric to the air-pipe size. This piece of pipe was then put into the underground run of air pipe about five feet from the compressor in such a manner that it would drain in the direction of the flow. The slamming of the valves was completely stopped. This compressor had positive intake and disk discharge valves. P. L. WILLIAMS.

Chicago, Ill.

As the Other Fellow Sees It

WHERE THE MAN WHO AGREES OR DISAGREES WITH AUTHORS OR EDITORS HAS A CHANCE TO SPEAK UP

Widespread Patent Applications

IN LOOKING through some back numbers of *Power,* I came across an editorial of June 30, which I had previously overlooked. It is entitled "Application Patents" and refers to an objectionable practice that has developed among European engineers—in the taking out of patents for every conceivable application of standard equipment and machines, many of which ideas have already been in use for several years.

In the first place, are European engineers alone in this, more or less, nefarious practice? The same practice is possible in this country, because the Patent Law allows the granting of patents relative to ideas that are already known and that may have been in use in actual practice. The remedy lies in modifying the Patent Law.

The taking out of patents relating to ideas that are already public property is not possible in all countries. In Great Britain, for example, it is not possible to obtain a patent relating to an invention that has been made public before the application has been filed in the Government Office in London.

At the present time there is considerable congestion in the Patent Office in this country. It requires, in some cases, two or three years to obtain a complete patent. Means should be taken to reduce this length of time.

In this country the examiners investigate patents of other countries as well as those of the United States when dealing with an application for a patent. In Great Britain the examiners investigate British Patents only, for fifty years prior to date of application. The only advantage of investigating, or searching, the patents of other countries, as is practiced under the United States law, is that the patent, when granted, is somewhat stronger than it would otherwise be. It would considerably relieve the congestion in the Patent Office if the law was so changed that only past United States patents were searched.

Cambridge, Mass. STANLEY G. WELBURY.

* * * *

Applications of Squirrel-Cage Motors Extended

IN THE issue of Sept. 25 there is an article by E. F. Rogers, entitled "Applications for Squirrel-Cage Motors Extended," which is interesting and instructive, but I believe requires some extending if the facts concerned are to be fully understood.

Mr. Rogers speaks of the high-resistance squirrel-cage motor as being something new. This type of motor has been used for elevators since 1906 and has been regularly distributed by my company since that time for this purpose. During that period all slip-ring motors have been practically eliminated on elevators and have been replaced with this type of machine. The high-resistance squirrel-cage motor is being used on exacting work requiring up to 400 starts per hour.

The two other types mentioned, the double-squirrel-cage and buried squirrel-cage, have been known as long, but have never been commercially manufactured until lately, because the power companies' requirements regarding starting current would not allow a machine of this type to be used. These types have certain advantages and also disadvantages. They will reduce the starting current by about 30 per cent and increase the starting torque over the standard squirrel-cage motor by about 10 per cent to 20 per cent, depending on design. They, however, have the disadvantage of a slightly increased cost and a reduction in maximum capacity of about 35 to 40 per cent. Their power factor is appreciably lower than for a standard squirrel-cage motor, and their slip is higher. They could not be commercially used now were it not that the power companies are more generous in their allowed starting current than they were some years ago.

As a matter of fact there are at the present time but few places where, from a strictly engineering and economic point of view, a slip-ring motor can be justified.

J. F. LINCOLN, Vice-President,
Cleveland, Ohio. The Lincoln Electric Company.

* * * *

Engineers Who Wrote History

IN THE Sept. 18 issue, there was a short description of James Watt, which is in part so opposed to the real facts of the case that I shall be grateful if this letter is published.

In the first place, it was not exactly chance that brought James Watt into contact with the Newcomen engine. As is well known, he was instrument maker and repairer for the University of Glasgow, and included in the regular equipment of the Engineering Lecturing Department was a working model of a Newcomen engine for demonstration purposes. For some reason or other this went wrong, and James Watt had to repair it in the course of his ordinary work. It was while engaged on this matter that he hit upon the idea of the separate condenser, that is, taking the steam out of the cylinder and condensing it in an arrangement specially designed for the purpose, replacing the crude method used by Newcomen of simply squirting cold water into the cylinder.

With regard to the statement, "Owing to his business acumen the firm of Boulton & Watt prospered," the facts are notoriously that Watt had no business ability whatever, and it was almost entirely due to the eminence in this connection of Matthew Boulton that the Watt engine ever became a practical proposition. As a matter of fact James Watt was an extraordinary man in many ways, but his great idea of business was to make as few engines as possible so that there was less risk of their being copied by competitors.

James Watt was miraculously lucky in meeting a man like Matthew Boulton, who was a business expert with a large works of his own, a wealthy man, and honorable in the sense that he carried out his bargain with James Watt in connection with the sharing of the profits. If it had not been for this, unquestionably Watt would

have died in misery and poverty, like most of the other great inventors in the world. Apart from his entire lack of business knowledge he was peculiarly, shall we say, stupid and in many ways unscrupulous.

It was stated that he spent much of his later life in fighting steam-engine improvements developed by others. This is correct, although in some cases, of course, the people he fought were thieves who had stolen his designs. The worst example was his blackguarding of Richard Trevithick, who, it may be remembered, made one of the greatest advances in engineering history in the production of the high-pressure Cornish boiler, called after his native County of Cornwall. This was invented in 1797, and James Watt fought tooth and nail because it immediately enabled steam to be used at 25 lb. pressure instead of the 6 lb. always employed by Boulton & Watt. As a matter of fact Watt himself was compelled at the finish to go up to 10 lb., and it may be remarked that the firm of Boulton & Watt made every possible effort to get a bill passed through the House of Commons in Great Britain to render the use of steam above 6 lb. illegal, so as to protect their own business and retain the monopoly of an antiquated type of engine.

Boulton & Watt, and James Watt, prevented their employee, the famous William Murdoch, from developing the steam locomotive and did their utmost to stop him from going ahead with the town gas industry, which, it will be recollected, he originated on a practical scale by lighting Boulton & Watt's works in Birmingham with gas in 1802 to celebrate the Peace of Amiens. This was the first industrial establishment so illuminated.

London, England. DAVID BROWNLIE.

* * * *

Does the Home-Made Policy Pay in the Power Plant?

IN REPLY to the letter of L. G. Jones in the July 10 issue, "Does the Home-Made Policy Pay in the Power Plant?" it has been my experience that some of those home-made inventions to which he refers pay exceedingly well.

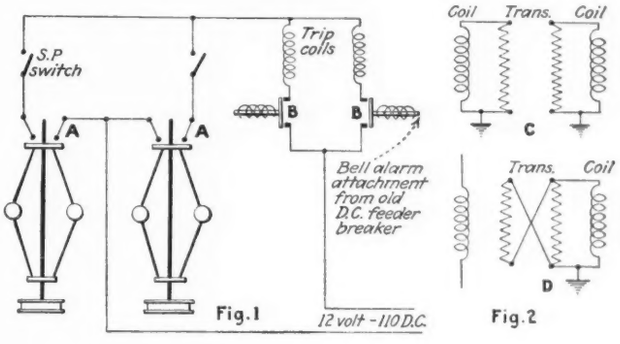
In our medium-sized central station here in New England we have two dual-driven removable pumps on a twin-jet condenser. Now it so happens that most of the time our entire load is carried on one main unit of 12,500 kw. capacity. Of course any heavy disturbance on the system drops the frequency of the main unit, and this in turn drops the speed of the removal pumps. (We run on the induction motors normally to hold our heat balance.) As the pumps slowed down, the water would build up in the condenser, finally tripping the vacuum breaker, and this made it necessary to lighten the load until we could pick up the water again—a very annoying condition, to be sure. However, it existed for some time.

In the first place it was impossible to have the governor in a closed position at normal running speed so as not to blow steam through the turbines, and then have it maintain running speed when the motors were off. We did not need the steam for heating feed water, as we had plenty of waste steam from essential auxiliaries.

It was an easy matter to rig up a spring in opposition to the governor spring, in other words, to hold the valve operated by the governor on its seat while running at normal speed. This was arranged with a figure-four latch so that the slightest movement of the governor released the latch, allowing the spring to disengage. The governor then opened the valve to the running position.

In the second place, no provision was made to release the switches on the motor circuits after the steam end had taken the load. One can easily see what the result would be. After the steam end came in, trying to maintain normal speed, the motors acted as generators. Owing to the fact that the system frequency was low at this time, as was always the case when the turbines automatically came in, this held the speed down and allowed the water to build up in the condenser.

The second difficulty was finally overcome by means of two old engine stops. These were used to prevent overspeed on reciprocating engines and consisted of small flexible Pickering-type governors. Contacts were arranged so that when the engine overspeeded a circuit was closed through the governor and this released a latch which allowed a weight to drop and close the throttle. The contacts on the stops were simply turned around so that the circuit was closed when the governor dropped below speed. Then a special pulley was made and the stop belted to the pump shaft. At normal running speed the contacts were in the open position. We set them to close when the speed dropped sixty revolutions, which



Arrangement of contacts and connection used to open motor circuits on dual-drive exciter

was equivalent to two cycles on the main unit. However, it was possible to set them as close as five revolutions difference.

The switches controlling the motors were the regular 440-volt inclosed-type manually operated oil switches. Each was equipped with a low-voltage release connected across the 440 volts and two current coils operating from two-current transformers in the leads to each motor, as shown at *C*, Fig. 2. These two-current coils were arranged as shown at *D*, two transformers on one coil and the other coil free. This free coil was connected in series with the stop and a twelve-volt battery circuit, which was opened when the oil switch opened. The bell alarm attachment was mounted on the frame of the oil switch, so that when the oil switch was in an open position the circuit was broken. From the foregoing explanation and the illustration it is readily seen that when the governor drops in speed and closes the contacts at *A*, the trip coil is energized and the oil switch opens. This opens the contacts at *B* and takes the coil out of circuit. The reason for this attachment was to prevent the coil from being left in circuit when the pump was shut down.

The arrangement for both pumps is as shown in Fig. 1. However, the shunt trip coils were later replaced with 110-volt coils and operated from the operating bus.

Although only a home-made device, it has operated perfectly for over six months and we believe it will continue to do so. GEO. C. TRAPP.

Branford, Conn.

What's New in Plant Equipment

HOW THE MANUFACTURER CONTRIBUTES TO THE JOB OF GENERATING TRANSMITTING AND APPLYING THE POWER SERVICES

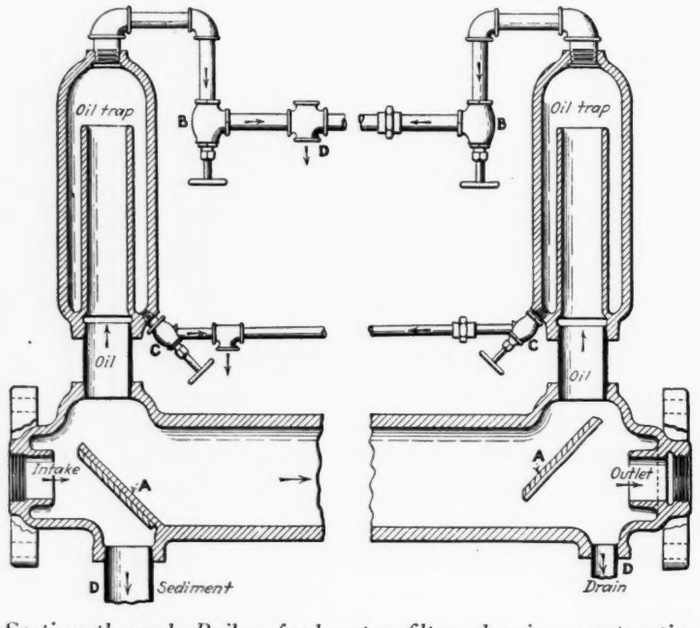
Bailey Feed-Water Filter

THE accompanying illustration shows in section a new feed-water filter designed by A. R. Bailey to remove sediment and oil from the feed water and, in so doing, prolong the periods between boiler washings. Its location is between the pump and the boiler, being placed on the boiler side of the heater if the latter is of the open type, and on the pump side of a closed heater.

Operation of the filter may be traced from the drawing. Upon entering the intake, the feed water strikes the cast-iron baffle *A*. With the slowing down in velocity from entering a larger area and the change in direction of flow, the sediment and heavy burned oil are cast down into the drain and the lighter oil is carried upward into the oil trap, where it accumulates in the concentric space around the inner pipe. Similar action takes place at the discharge end of the filter.

As often as may be necessary, depending upon the volume of the flow, the filter may be blown down. First the valves *B* are opened to allow the oil at the top of the traps to pass out through line *D*. Then the collection of oily water in the jacket spaces of the traps is forced out through valves *C*, and finally the sediment is flushed out through the drains provided for this purpose.

The results obtained from the units now in service and various samples of oil taken from the traps indicate that the device is fulfilling the claims made for it. The Baker Valve Company, 1847 East 28th St., Minneapolis, Minn., has the manufacturing and sales rights for the United States, Canada and Mexico.

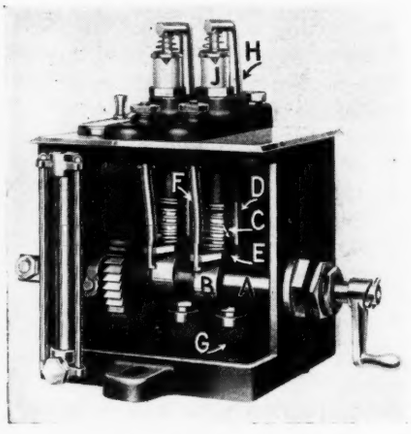


Section through Bailey feed-water filter, showing construction and method of operation

Force-Feed Lubricator with Individual Removable Pumping Units

A TYPE of force-feed lubricator (Model F) in which one pumping unit is used for each feed and is entirely separate and removable from the reservoir without disturbing any other unit, has recently been brought out by the American Oil Pump & Tank Company, Cincinnati, Ohio.

Referring to the illustration, which shows a twin-feed model, each pumping unit is driven by the shaft *A*, fitted with a cam *B* for each unit. As the shaft is rotated, the cam raises the plungers *C* and *D* on the delivery stroke, and they are lowered again on the suction stroke by a spring on the plunger *C* acting on the plate *E*. The plungers are raised to the same height at all adjustments of the stroke, the length of the stroke being adjusted by limiting the downward travel by means of the rod *F* and knurled nut on the top of the pump body.



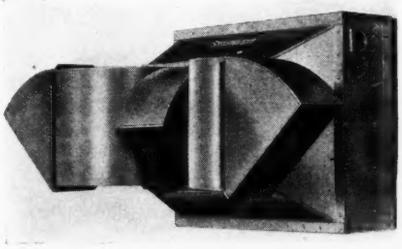
Cutaway view of Model F lubricator

At the downward stroke of the plunger *D*, oil is drawn through the screen *G* and the suction line to the cylinder *D*. On the upward stroke this oil is forced through a check valve and nozzle *H* and sight-feed glass *J* to the cylinder *C*. On the upward stroke of the plunger *C* the oil is forced through another pair of check valves into the discharge-line connection at the back of the pump.

A heating chamber is provided in the oil reservoir so that the oil can be heated when heavy oil is used or when the oil is exposed to low temperatures. The shaft *A* is driven through a ratchet and pawl, and an auxiliary crank is furnished for supplying extra oil at starting or for supplementing the regular feed. The drive can be changed from right to left or vice versa, and a rotary drive can be used where desirable.

Tempervane Heating Units in Suspended and Floor Types

HEATING units in both the suspended and floor types, fitted with Aerofin heating elements suitable for pressures up to 350 lb., have recently been added to the line of heating and ventilating equipment put



Suspended type unit with three-way discharge

out by the B. F. Sturtevant Company, Hyde Park, Boston, Mass. The two types of heater have been designed to provide a flexibility of installation that will cover practically every requirement. The type illustrated can be suspended from walls or ceilings and the floor type is designed to permit installation in narrow spaces between floor columns or against the walls of a room.

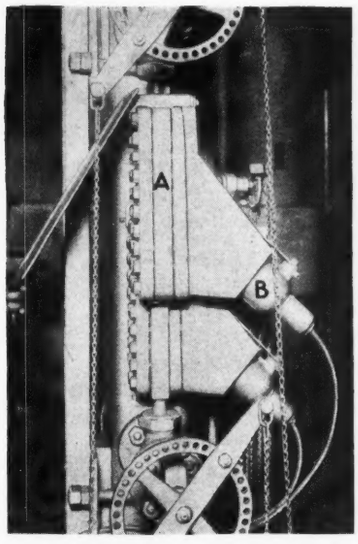
The heating element is the standard Aerofin, which consists of a copper tubing having a fin of copper ribbon wound helically around it and soldered. The air is passed through the unit by one or more motor-driven propeller-type fans designed especially for this service. It is pointed out by the manufacturers that the horsepower of this fan is lower at 100 per cent wide-open air discharge volume than when the fan is entirely closed off. This gives a comparatively flat horsepower curve and makes the unit virtually self-limiting in horsepower characteristics. The motor used to drive the fan is of the totally inclosed type with special dust-proof, grease-packed thrust ball bearings. Single-phase motors are of the condenser type.

The outlet is built for one-, two-, three- or four-way discharge, and a large diffusing chamber is provided between the fan and the heating section in order to permit uniform distribution of the air over the heating surface. In installations where a steam pressure below 50 lb. is required the low pressure heating elements can be used.

Water-Column Illuminator for Flat-Type Gage Glasses

IN THE Dec. 11, 1923, issue, the water column illuminator put out by the National Company, Boston, Mass., was illustrated and described. This illuminator has recently been made adaptable to single and multiple flat gage glasses as now used on high-pressure boilers, consisting of thick, flat plates of glass bolted into heavy castings, as shown at *A* in the illustration.

In the round glass type illuminator that was previously described, the gage glass was illuminated by two



Illuminators in position on a high-pressure double-glass mounting

directed light sources, and the reflection of the directed light beams by the meniscus at the water level.

In the new type-D illuminator illustrated, the same lighting unit *B*, with its condenser lens and special air cleaning jets, is used. This is surrounded by a special casing which supports the illuminator in the rear of the gage glass and which is designed to prevent a light from passing anywhere but through the glass. As will be apparent from the illustration, the light is thrown upward at an angle at the rear of the glass, and this produces a reflection from the underside of the water surface, or meniscus. The type-D unit shown in the illustration is adaptable to either single or multiple flat gage mounting. The casing has a single clamp which hooks over the top of the glass mounting and fastens with a single set-screw.

Motor-Driven and Gas-Engine-Driven Arc Welders

STATIONARY and portable types of direct-current motor-driven and gas-engine driven arc welders have been brought out by the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa. In Fig. 1 is shown the portable type welder, which may be driven by either a 230- or 550-volt direct-current motor. This set is suited to applications where only direct current is available. In Fig. 2 is shown a gas-engine-driven welder which is driven by a Model P-20 four-cylinder Continental engine direct connected to a 200-ampere generator. The motor-generator sets have a common frame for both units, and the common shaft is supported by ball bearings. The rating of the generator is in accordance with N.E.M.A. standards, being 200 amperes with one-hour, 50-deg. rise on a resistance load of 25 volts. The welding range is 60 to 300 amperes. The driving motor is compound-wound and maintains constant speed with a voltage fluctuation of not more than 10 per cent. The generator is a single-operator,

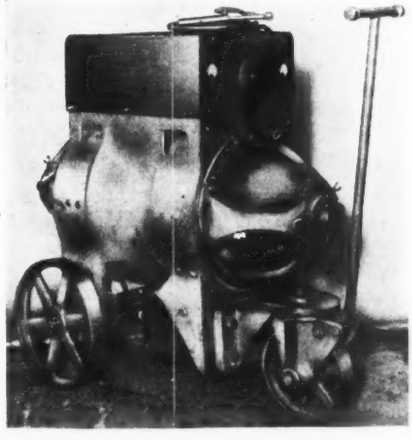


Fig. 1—Portable type motor-driven welder

constant-current, differentially compound-wound type, and is separately excited from the line. The field rheostat of the generator gives a one-dial adjustment for the entire welding range. The control is mounted at the front on the upper part of the frame, and is protected by a metal cabinet.

In the engine-driven set the engine and generator, complete, with all controls, are mounted on an all-

welded channel-iron base which can be made suitable for either stationary or portable use. The engine is rated at 24 b.hp. at 1,450 r.p.m. The carburetor is fitted with a friction-type choke operated by a positive centrifugal-type governor. The lubricating

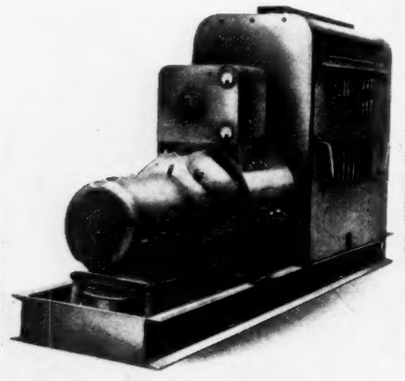


Fig. 2—Engine-driven stationary welding unit

system is pressure fed by a gear-type pump. A centrifugal water pump and large radiator comprise the cooling system. The generator is the same as on the portable set.

Curtis Type T Return Trap

SIMPLICITY of design, few moving parts, one-point valve adjustment and packless gland on float shaft are important features of the Curtis type-T return trap, recently brought out by the Julian D'Este Company, Boston, Mass.

The trap consists essentially of a stationary receiver and three valves—a pilot valve, an equalizing valve and a vent valve—all of which are outside of the receiver. The pilot valve *A*, Fig. 1, is operated directly by the float through the shaft *B*, which is fitted with a packless gland shown in detail at the right of Fig. 2. The steam or equalizing valve and the vent valve are operated by air or water pressure under control of the pilot valve. The equalizing valve serves to admit steam pressure to the receiver to effect the discharge, and the vent valve to relieve the pressure in the receiver when the discharge is completed. The movement of these two valves is synchronized, the vent valve being closed while the steam valve is opened and vice versa. As will be seen from the illustration, there is only one valve adjustment *C* on the trap, which alters the travel of the pilot valve in relation to the float.

In operation condensate enters at the top of the receiver and, as the float rises, it actuates the pilot valve, which in turn admits air or water

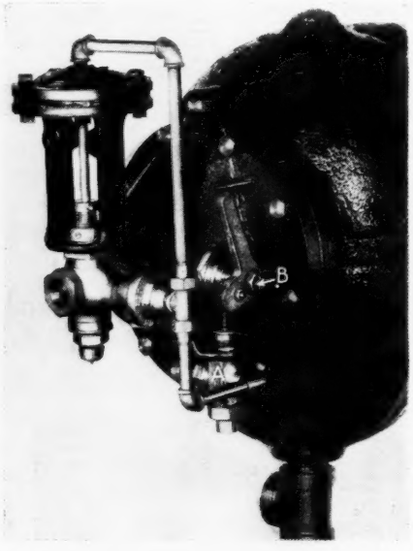


Fig. 1—View of trap showing arrangement of pilot, vent and equalizing valves

pressure to the diaphragm chamber of the equalizing and vent valves. This pressure opens the equalizing valve and closes the vent valve. When the equalizing valve opens, steam enters the receiver and the condensate is discharged through the connection at the bottom. As the float reaches the bottom, the pilot valve closes, cutting off the pressure. This allows the equalizing valve to close and the vent valve to open. The cycle of operation is then repeated.

In the design of the gland on the float shaft, shown in Fig. 2, the usual stuffing box is eliminated and the sealing is effected by means of a collar on the shaft held against the composition washer *D* by a spring at the other end of the shaft. With this design friction is reduced to a minimum.

The trap is made in six sizes numbered 0 to 5 with inlet and outlet connections, steam-valve size and capacity, as a boiler feeder, as follows: No. 0, $1\frac{1}{4}$ in., $\frac{3}{4}$ in., $\frac{1}{2}$ in., and 1,080 lb. per hour, and the No. 5, 3 in., $2\frac{1}{2}$ in., 2 in., and 16,800 lb. per hour, respectively.

The trap is equally adaptable to high or low pressures and can be used as a lifting trap for handling gasoline, oil and other liquids. In this service the capacity of the trap is increased somewhat over that when used as a boiler feeder, the No. 0 having a capacity of about 1,860 lb. and the No. 5 28,000 lb., as compared with the capacities previously given. The intermediate sizes Nos. 1 to 4 have corresponding capacities.

Plug Fuses With Colored Tops

PLUG fuses with colored tops, a color for each size, are being introduced by the Trico Fuse Manufacturing Company, Milwaukee, Wis. The idea behind the use of the color is that it enables the user to know readily the capacity of the fuse; it being easier to remember a color than the ampere rating. The different colors used are as follows: All fuses 0 to 6 amperes have a brown top; 10 amperes, yellow; 15 amperes, blue; 20 amperes, pink; 25 amperes, red, and 30 amperes, green.

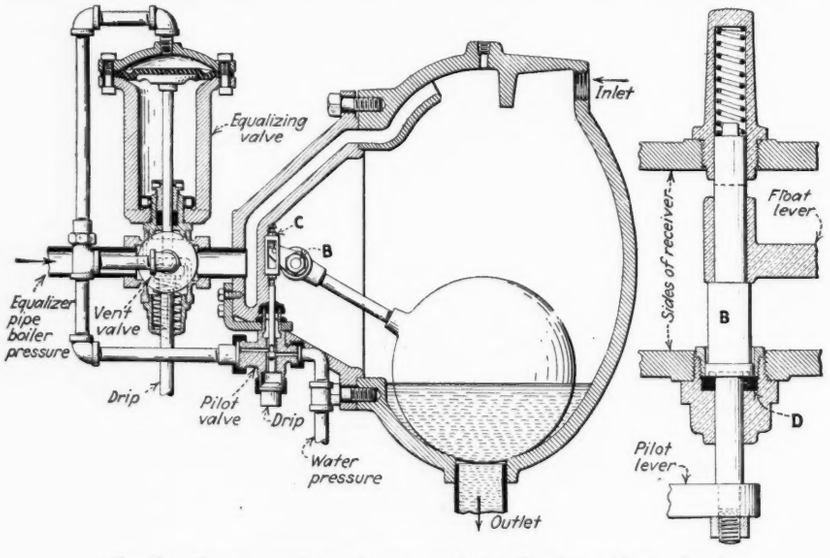


Fig. 2—Cross-section of trap and detail of packless gland

Fuel-Oil Requirements

for Heavy-Oil Engines

In a paper presented before the Fuel Conference, World Power Conference, London, Sept. 24, 1928, Harold Moore outlined the characteristics of various fuels suited for oil engines. As will be seen from this abstract, he does not place any great stress on viscosity, but lists tests of specific gravity, ash content, coke value and hard asphalt percentage.

THE oils available for Diesel-engine use may be classified according to their origin into petroleum, shale oils, coal-tar products, lignite-tar products, wood-distillation products, animal and vegetable oils. All these oils have been used, but the bulk of those used at present are of petroleum origin.

Though the makers of Diesel engines frequently state that their engines will operate on high-gravity residual oils, the oils actually used on the majority of engines, both for land and marine service, are either distillates or very light residuals.

Cheap Low-Gravity Residuals

At the present time, as the petroleum industry is suffering from over-production and ample supplies of low-gravity residuals are available at low prices, there is no incentive to use heavy residues as in the past.

Although a great variety of tests have been devised and are useful on special occasions for the valuation of petroleum fuel oil, in the majority of cases the quality can be gaged by means of the following eight tests: Specific gravity; closed flash point; cold test; heat value; ash content, with comment on the nature of the ash; water content; coke value and hard asphalt.

It will be observed that several important tests have been omitted, most notably the viscosity and the soft asphalt content.

The shale oils are chemically very similar to the petroleum oils, but being produced by a process of destructive distillation, they are comparatively free from asphaltic matter.

Raw-Coal Tars Vary in Composition

The raw coal tars vary greatly in composition, according to the nature of the coal from which they originate and also according to the plant in which they have been produced. The latter appears to have a greater effect. Unlike the petroleum and shale products, the tars are rich in oxygen and contain compounds such as cresols; the high-gravity tars obtained by high-temperature distillation are also rich in a substance known as "free carbon," a finely divided coke-like substance which is insoluble in the body of the tar.

The coal tars have been burnt on heavy-oil engines with more or less success. Those of high free-carbon content, such as some of the horizontal retort and coke-oven tars, have not been found satisfactory, but a great deal of vertical retort tar has been employed in Germany. This fuel appears to have given the greatest satisfaction on large two-stroke-cycle Diesel engines, probably on account of the absence of exhaust valves, which appear to be the most sensitive part of the engine when refractory fuels are being burnt.

Spontaneous Ignition Temperatures

All the coal-tar products, whether raw tars or distillates, possess comparatively high spontaneous-ignition temperatures and, therefore, do not ignite in a Diesel engine with the same ease as petroleum products. Several methods have been adopted for overcoming this difficulty, the most obvious being to raise the compression ratio of the engine. As, however, very high compression pressures are inclined to cause mechanical trouble, this method is not particularly satisfactory, and in many cases users have employed normal compression ratios which will operate satisfactorily when the engine is running on heavy loads, but which are insufficient to bring about ignition under starting conditions. To overcome this difficulty, the engine has been started up on petroleum oil and run on this fuel until it is thoroughly warmed. A still more satisfactory method is by the use of pilot ignition gear, whereby a small charge of petroleum oil is introduced into the cylinder immediately prior to the main charge of the coal-tar product. The quantity of ignition oil required is usually approximately 5 per cent of the fuel.

With the use of this gear practically all the higher boiling coal-tar distillates may be used in heavy-oil engines.

Low boiling products, which are highly unsaturated, are likely to oxidize with the formation of varnish-like constituents, and this has been found to give trouble on engines operating with an air blast. This difficulty can probably be overcome by mechanical means; that is to say, by a slight alteration of the pulverizing devices.

There is no question of the suitability of coal-tar products. If available at economic prices, they are perfectly satisfactory fuel for Diesel engines. They possess a slightly lower heat value, but experience has shown that, probably on account of their lower viscosity, they give a slightly higher thermal efficiency than petroleum oils. In the event of a petroleum shortage there is no doubt that they would be largely used as Diesel-engine fuels.

Distillation

Tars obtained by low-temperature distillation are generally suitable for use without distillation, provided they are comparatively free from free carbon, ash and water. As many of these tars are badly emulsified with water when first generated, they often require a drastic centrifugal treatment. Although they are not usually as difficult to ignite as the coal-tar oils, special precautions are necessary to insure complete combustion.

In spite of their fundamentally different chemical constitutions, these oils behave similarly to petroleum products when used as fuels for Diesel engines. The animal and vegetable oils are glycerins and, on account of their oxygen content, possess a lower heat value than hydrocarbon products. The spontaneous-ignition temperature of whale oil was found by the author to be little different from that of petroleum fuel oil. Actual experience also showed that the pilot ignition gear used for tar oils is quite unnecessary when burning saponifiable oils.

Specific Gravity Tests

The specific-gravity test gives an indication of the nature of the chemical bodies present in the oil and, although it is of no direct importance, it is useful for purposes of classification. A high specific gravity indicates the presence of aromatic hydrocarbons, cresols or asphaltic bodies. The appearance gives a good indication as to whether the oil is asphaltic or not, so that by taking into account the appearance and the specific gravity, a rough estimate as to the nature of the product may be formed.

The flash point, which may be determined by either the closed or open method, is merely of value in indicating any danger of fire that may be encountered during transport and storage.

Viscosity is generally considered to be an indication of the asphalt content of a petroleum oil, but the presence of asphalts can be estimated more effectively by other methods. Extremely viscous oils do not flow easily,

and trouble is experienced in making them flow from the service tanks to the fuel pump. A low viscosity is an advantage, because mobile oils generally pulverize better and consequently burn with a higher thermal efficiency. The viscosity, therefore, indicates the type of pulverizing device most suitable for the oil, thus comparatively restricted settings can be used with thin oils, whereas more open settings are necessary in order to obtain full load with highly viscous oils.

Effects of Sulphur Content

There appears to be no direct relationship between the sulphur content of an oil and its behavior in an engine. Apart from a few cases of silencer corrosion, no deleterious effects resulting from the use of oils of high sulphur content have been observed. When sulphur is present as a constituent of hard asphalt, it may, however, present quite serious difficulties, but it is better to consider these the result of the presence of the hard asphalt rather than the effect of the sulphur.

Water is generally present in petroleum oils in the form of a suspension or, in large quantities, as a layer at the bottom of the tank, while in coal-tar oils a certain amount is present in solution. A little water present in solution gives no trouble, and its only effect is to lower the heat value slightly. Water that is not in solution and consequently not evenly distributed throughout the oil, may, however, cause serious trouble. Usually, little difficulty is encountered if the water content is below one per cent.

The mechanical impurities are the bodies insoluble in organic solvents, such as xylol. They rarely present any difficulty except when the ash content is high; the mechanical impurities are then identical with the substances responsible for the ash.

Ash in Lubricating Oil

The major portion of the ash is, probably, blown from the exhaust valve or exhaust port, but a comparatively small proportion accumulates in the lubricating oil. Eventually, this forms a pasty mixture which may prove very erosive and result in rapid wear of the piston rings and the liner. The amount of erosion is dependent upon the nature of the ash. Some ashes, containing vanadium oxide, iron oxide or silica, are very erosive, while others consisting of sodium compounds are comparatively non-injurious. It is usual in specifications to limit the ash content to 0.05 per cent, but if the ash is of a non-erosive nature, this figure may safely be increased.

The coke value is a comparatively simple test carried out by heating the oil in the absence of air until all the distillable products have been driven off and a residue of coke remains. The figure is practically a measurement of the amount of asphalt present and is very useful on this account. High coke value indicates the presence of hard asphalt or of larger quantities of soft asphalt.

Hard asphalt is likely to cause coke formation in the engine, smoking at the exhaust and injuries to the exhaust-valve face, when poppet valves are in use. With port-scavenged two-stroke-cycle engines the exhaust valve difficulty is not encountered and large two-stroke-cycle engines operating at comparatively slow speeds actually give better results when burning oils of high hard asphalt content.

In deciding the nature of the oil on a Diesel engine, it is necessary to make allowance for the design at the engine itself. This factor can be judged only by experience, but large, slow-running engines are generally capable of burning asphaltic oils better than smaller and faster-running engines. Engines on variable loads are more sensitive and operate better on distillate fuels.

Another point that has to be considered is the mean effective pressure at which the engine has been rated. Difficulty may be experienced in burning a given oil at full load in an engine rated at a very high m.e.p., whereas it may give no trouble at a somewhat lower rating.

The method of injection also influences the capabilities of an engine for burning heavy fuel. In the past the author considered that engines provided with compressed-air injection could burn the heavy oils more efficiently on account of superior spraying and turbulence. Mechanical injection has now been greatly improved, and at the present time there is probably little to choose between the two systems.

Thoughts on Welded Pressure Vessels

Some interesting experiences in the manufacture of pressure vessels by oxy-acetylene welding were presented at the spring meeting of the American Welding Society by A. O. Miller, vice-president, Reeves Brothers Company. This experience led to the following concluding remarks by Mr. Reeves:

"The welded type of vessel offers possibilities to any manufacturer using pressure vessels—first, in that it is absolutely tight against leakage of any sort, even of the most volatile liquids. Second, if it is desired to use a different process, welded vessels can be cleaned very readily and easily. Contamination of the second material used by material left in riveted joints or seams from the first operation is avoided.

Third, while the original cost of the installation may be somewhat higher this is more than offset by flexibility of operation and exceptionally low maintenance costs. Fourth, safety is increased by having a vessel with a known safety factor of three or more. With present designs of riveted vessels, no one is sure of more than a factor of 1½, as this is all that is provided for in riveted vessel construction tests.

"In choosing our men for welders on this class of work, we endeavor to pick from our plant employees men whom we know to be reliable, steady, sober, and conscientious, and whom we feel can be depended upon to follow strictly any rules or regulations laid down to them to follow. Then we put them to work first in the fitting-up gangs, tending generator, gas cutting, doing small odd jobs of welding not requiring any specific strength or test, with the idea in mind that they will absorb a considerable amount of knowledge of the actual welding by being in close contact with the men welding on the vessels.

"They are finally permitted to weld test pieces, which are cut and broken at our plant and the results shown them as to penetration, fusion, laps, etc. Possibly after tests such as the above, we permit them to make a tensile test plate, which is sent to some authorized testing laboratory for testing. No welder has been permitted to weld on important work until all six pieces cut from a test piece have passed 45,000 lb. tensile test.

"The tensile requirement on test pieces has now been raised to 50,000 lb. and our welders have satisfactorily passed tests at this figure."

Heat Conservation in Clay Works

A RECENT article in the *Power Engineer* cites an excellent example of what can be done toward increasing the economical use of fuel in the clay-working industry by the application of modern heat-conservation principles.

The firm of Canby & Company, Ltd., manufacturers of firebrick, building brick, etc., until recently used live steam from their boilers to heat the drying floors of their Heathfield Works, in the County of Devon, England. On an average this service required about 211,000 lb. of steam a week.

With the installation of a tandem-compound vertical engine of 75 hp. and a single-cylinder engine directly coupled to a 35-kw. generator, exhaust steam at two pounds pressure was made available for this purpose. The floors comprised 27 brick chambers, the majority of which measured 25 ft. by 10 ft. by 1 ft. deep, covered with iron plate. The exhaust steam is admitted to these chambers through 1-in. pipe, and drainage is effected by simple stoneware traps. With the use of exhaust steam drying of the same brick output requires on the average 181,000 lb. a week. In addition to the use of exhaust steam for drying, some of the heat ordinarily lost by radiation from the kiln is reclaimed for this purpose.

Prior to the changes the coal consumption for July to December, 1925, was 1,204 tons and July to December, 1926, 1,224 tons, whereas for the period July to December, 1927, it fell to 629 tons, in spite of the addition of live-steam demands equivalent to about four tons of coal and minor additions of load on the generating plant.

This is a signal justification of the use of exhaust steam from the power plant for industrial processes.

Events and Men in Power's Field

THE EDITORS WILL WELCOME THE CO-OPERATION OF READERS IN REPORTING INTERESTING HAPPENINGS, PERSONAL OR OTHERWISE

World's Largest Telegraph Building To Have Emergency Power Plant

ARCHITECT'S drawing of the new Western Union Telegraph building for which ground has just been broken in lower Manhattan. In order to insure the certainty of operation of the telegraph equipment, the building is to contain a small power plant, consisting of a motor-generator unit for operation on the a.-c. service if both incoming d.-c. feeders fail, and a Diesel-driven generator and storage battery for use when all outside supply is cut off.

Ground Broken Recently for New Duquesne Plant

Officials of the Philadelphia Company, representatives of Pittsburgh's City Council, and others recently attended the ground-breaking ceremonies for the new 60,000-kw. capacity steam-electric generating plant in Pittsburgh of the Duquesne Light Company, one of the Standard Gas & Electric Company group of utilities. The new station is to be known as the James H. Reed Power Station and is named for the late Judge James H. Reed, who organized the public utilities of Pittsburgh, which are today grouped under the Philadelphia Company, and who served for twenty years as president of the corporation.

The station will be adjacent to the Duquesne Light Company switchhouse and near the present power station on Brunot Island, and the cost of the initial installation will be approximately $9,000,000. The power house building will be large enough to house two 60,000-kw. turbine-generators and six boilers, but at present only one 60,000-kw. unit and three boilers will be installed, provision being made for further extension to the station. It is estimated that the ultimate station will cost approximately $13,500,000.

Construction of the James H. Reed Station on Brunot Island is due to increased demand made upon the Duquesne Light Company for electric service, especially in view of industrial development in the City of Pittsburgh and vicinity. Plans for the station have progressed, according to H. W. Fuller, vice-president in charge of engineering and construction, Byllesby Engineering and Management Corporation, to the point where actual construction work is expected to start in December.

St. Lawrence Project Causes Opposition

The Beauharnois Light, Heat & Power Company, of Montreal, is preparing to go ahead with the big project authorized by the Quebec Legislature for the further utilization of the St. Lawrence River power by a canal between Hungry Bay and Melocheville. A public hearing of the matter at which all the interests will be represented will be held shortly. Frank P. Jones, former president of the Canada Cement Company, has accepted the presidency of the new power company and is devoting much of his time to the new enterprise.

Established hydro interests, including the Cedar Rapids Power Company and the Canadian Power Company, are opposing the project on the grounds that their rights will be adversely affected, a claim which the new company denies. These same interests unsuccessfully opposed the legislation enacted by the Quebec government last winter. Proponents of the project, in pressing their application before the federal government at Ottawa, represent that a great industrial development on new lines, in the Montreal and Beauharnois districts is assured if the new plan already thoroughly financed, is approved by the Dominion Government.

A. S. H. & V. E. Annual Meeting To Be in Chicago

The 35th annual meeting of the American Society of Heating and Ventilating Engineers has recently been announced for Jan. 28 to 31, 1929, and is to be held in Chicago, Ill. The Edgewater Beach Hotel has been selected as headquarters for the meeting.

Arrangements will be in the hands of the Illinois chapter of the society, and the Arrangements Committee has already been chosen by that body. It consists of H. G. Thomas, general chairman, assisted by J. A. Cutler, J. H. O'Brien, T. H. Monaghan and L. L. Narowetz. The Illinois group has promised that this meeting will be a record breaker in many ways and is strongly urging the membership to attend in force.

McGraw-Hill Growth Brings About Division of Executive Leadership

James H. McGraw continues as chairman of the board—Malcolm Muir elected president—Changes, in line with current expansion, take effect at once

RECENT growth and expansion of the McGraw-Hill Publishing Company have led to action by the Board of Directors, it was announced Oct. 31, separating the offices of Chairman of the Board and President of the company, both of which have hitherto been held by James H. McGraw. Under the new plan of organization Mr. McGraw will continue as Chairman of the Board. Malcolm Muir, formerly Vice-President, has been elected President of the company and Chairman of its Executive Committee. James H. McGraw, Jr., Vice-President and Treasurer, has been elected Vice-Chairman of the Board, and Chairman of the company's newly-created Publishing Committee.

Malcolm Muir

Through merger and purchase in recent months the McGraw-Hill Publishing Company now comprises nine subsidiary and associated companies publishing business and industrial magazines, engineering books, catalogs and directories. Twenty-four magazines serving ten fundamental industries and covering business broadly are published at such widely distant points as New York City, Chicago, San Francisco and London. The direct effect of this coordination of related publishing interests will be to enhance publishing facilities for the group as a whole beyond those which any single paper or lesser group might enjoy. At the same time, the official announcement of the Board of Directors points out, these developments have greatly multiplied executive responsibilities and have necessitated a readjustment of the administrative duties of the company's principal officers.

Mr. Muir will be the chief executive of the McGraw-Hill Publishing Company, with full authority and responsibility for the operation of the company's business. He has been with the organization for the last 23 years and has been identified with many phases of its activities. During the last ten years particularly, he has taken an active part in each step of the company's growth. He has been a leader in the work of the Associated Business Papers, serving as president of that organization in 1925-26, and has been an important factor in raising the publishing standards of the business papers.

General Electric to Control British Group

A deal of considerable magnitude whereby the American General Electric group, through its British subsidiary, the British Thomson-Houston Company, obtains control of the Metropolitan-Vickers Electrical Company was announced a few days ago. It is stated that the Metropolitan-Vickers has acquired a large majority of the common stock of the British Thomson-Houston, the Edison Swan and the Ferguson-Pailin companies and also a large majority of preferred stock of the last-named company. H. C. Levis, chairman of the British Thomson-Houston Company, will become chairman of Metropolitan-Vickers, which will actually, it is understood, receive a new name and be used as a holding company.

Thus the British Thomson-Houston Company will acquire Metropolitan-Vickers and associate it with the Edison Swan and the Ferguson Pailin companies. Metropolitan-Vickers is capitalized at $33,000,000.

Although all this represents the taking over of control of a British company by American interests, a majority of shares, including voting shares, will be allowed to remain with British holders. This may offset the clamor raised recently in certain British newspapers over the prospect of control of British electrical enterprises falling into American hands. This was represented as an attempt to exploit a national scheme for electrical development in the interests of American manufacturers.

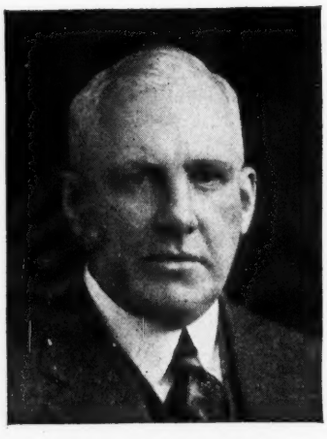
Stoker Manufacturers Issue Condensed Catalog

The Stoker Manufacturers Association, at its tenth fall meeting at White Sulphur Springs, recently brought out a new condensed catalog, the purpose of which is to acquaint the reader with the wide variety and applicability of the mechanical stoker. The catalog does not seek to advertise any make or type of stoker, but instead, describes all the prominent makes, devoting a column of type and one or more illustrations, to each make.

The catalog is in a way an encyclopedia of stoker information, giving the whole picture of underfeed, overfeed, and chain grate equipment. There are also several pages of theoretical data and tables, and a discussion of heat balance and other pertinent matters.

The catalog may be obtained from W. V. McAllister, secretary of the association, foot of Walker St., Detroit, Mich. It is a general compendium of information which should prove of great value to power engineers.

J. A. Smith, G. E. Schenectady Superintendent, Dies



James A. Smith

James A. Smith, superintendent of the Schenectady plant of the General Electric Company for the last fifteen years, and one of the most prominent Masons in the eastern United States, died Oct. 25 at his home in Schenectady. He was born in Hartford, Conn., May 25, 1873, and worked on a farm when young. In 1888 he entered the employ of Pratt & Whitney, in Hartford, Conn., about a year later entering the apprentice shop of that company. He was afterward sent to Chicago to install the Pratt & Whitney exhibit at the World's Fair and in 1900 was selected to install and demonstrate the company's exhibit at the Paris Exposition. From 1901 to 1903 he was associated with the Niles-Bement-Pond-Company and in 1905 was made superintendent of the Dutchess Tool Works, at Fishkill Landing, N. Y., which position he held until he entered the employ of the General Electric Company in 1910. His first General Electric position was at the Schenectady plant as assistant to the mechanical superintendent. In a few months' time he was made superintendent of one of the shops. He became general superintendent of the plant in July, 1913.

New Turbine Is World's Largest

A 147,500-hp. Westinghouse turbine-generator, now in operation at the Hudson Avenue station of the Brooklyn Edison Company, is said by company officials to be the largest steam turbine-generator in actual operation anywhere in the world.

Engineers of the Brooklyn Edison Company at the Hudson Avenue station admitted that their new unit will hold the world's record only until the Swiss-made unit now being installed in the Hell Gate power station of the United Electric Light & Power Company, starts operation next year. The Hell Gate unit will generate 160,000 kw., while the Brooklyn Edison unit generates only 110,000 kw.

The new Brooklyn Edison unit is the fifth to be installed in the Hudson Avenue station. The company says that when the station is complete it will have eight units with an aggregate capacity of about 1,000,000 hp., "making the station one of the greatest concentrations of power in the world," and with a capacity of furnishing current for the lighting of 1,000,000 homes.

Acetylene Association to Meet

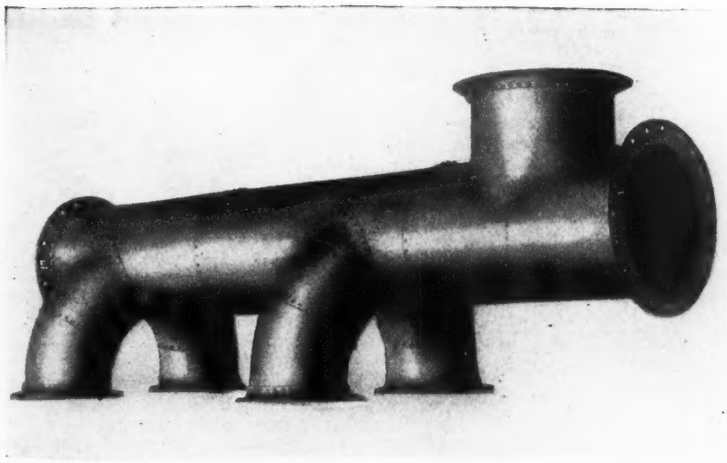
One of the outstanding features of the convention of the International Acetylene Association which is to be held at the Congress Hotel, Chicago, Nov. 14, 15 and 16, is a discussion of the report of the oxyacetylene committee of the association. This report is in fact the most complete and comprehensive survey of the uses of oxyacetylene welding and cutting which has ever been attempted. The report, which contains about 40,000 words, not only reviews almost countless articles that are fabricated by welding, but also touches upon details of particular interest in connection with the use of these processes in a number of the most important metal-working industries. This report is so comprehensive that it was considered too long for reading before the meeting and has therefore been printed for presentation to those who attend the convention, and a special time will be set aside in the program Thursday morning, Nov. 15, for open discussions of the different topics covered in it.

The technical sessions will include discussions by prominent engineers on such subjects as: "The Use of Acetylene in Times of Emergency," "The Use of Acetylene in Transportation," "The Cutting of Structural Steel," "Bronze Welding of Steel," "Acetylene in the Manufacture of Refrigerating Apparatus," "Hard Facing Metals," "Non-Ferrous Alloys," "Mechanical Welding," "The Effect of Tip-Size and Pressure on Economy of Cutting," and "Industrial and Domestic Piping."

Province of Quebec Yields More Power

Work is under way in connection with another big power development project in eastern Canada—the development of High Falls on the Lievre River, about 22 miles north of Buckingham, Quebec. This scheme is being undertaken by the MacLaren interests, and it is proposed to develop about 200,000 hp. The entire course of the river, stretching from High Falls to Mont Laurier, 108 miles farther north, will be affected by the project. It is estimated that the work will involve an outlay of between $40,000,000 and $50,000,000.

The lakes and rivers north of the Falls are to be raised 27 ft. to form a vast water-storage reservoir. This will mean the flooding of a great deal of surrounding country, including two villages and a large section of three other municipalities. Supplies are now being taken into the site and work will proceed on the construction of dams during the winter months. The power station will be erected next summer. This development will rival the present construction at Paugan Falls, on the Gatineau River, which is one of the largest power producers on the North American Continent.



A JUGGERNAUT of the future? Or the recently excavated fossil remains of the hitherto unknown Pipetheosaurus Steamus? *Neither guess is far from the truth. It is a low-pressure header built recently by a German firm.*

PERSONALS

GEORGE E. HAGGAS, for the last ten years chief engineer of the Cumberland County Power & Light Company, Portland, Me., has been appointed assistant general manager of that company.

J. S. JUST has resigned as engineer and manager of the City Electric Light Company, Brisbane, Australia, after an association of more than thirteen years. Mr. Just will establish a consulting engineering practice.

F. EDWARD O'NEIL has been elected vice-president and manager of the Diesel engine division of the Fulton Iron Works Company, St. Louis, Mo., and will have full charge of the company's Diesel and gas-engine business. Mr. O'Neil has been with the company since 1905 and has had an extremely wide and varied experience in most of its departments and branches, both in the United States and in foreign fields. For the last eleven years he has been in charge of the company's New York office, most of this time as vice-president.

E. A. STEWART, associate professor of agricultural engineering at the University of Minnesota, has resigned his position to become president of the Northwestern Public Utilities Company, with main offices in Minneapolis, Minn.

JOHN R. FISHER, of Marshall, Mo., has been retained by the City of Independence, Mo., to fill the vacancy in the operating organization of the municipal light and power plant caused by the resignation of O. C. Utter, formerly chief engineer. Mr. Fisher has had many years' experience in the operation of steam plants and has held a similar position at Marshall, Mo., where he operated the municipal light and water system for the last five years.

LEWIS PAYNE has been appointed general manager of the Virginia Public Service Company, and in addition, division manager of the central division, recently organized. The headquarters at Charlottesville, Va.

W. E. S. DYER, consulting engineer, of Philadelphia, Pa., recently sailed for Germany in connection with the installation of the 1,800-lb. power plant of the Philip Carey Manufacturing Company at Lockland, Ohio, mention of which was made in *Power* last week. The object of Mr. Dyer's visit is to approve details of design of the main

generating reciprocating engine units which are to be built for the Carey Company by A. Borsig, of Berlin.

Society Notes

A.S.M.E.—Metropolitan Section, New York City. Meeting, sponsored by the Power Division, Nov. 9, at 8 p.m. Subject: "Development and Recent Design of Stoker-Fired Equipment for Steam Generation."

A.S.M.E.—Iron and Steel Division, Chicago, will hold a banquet and meeting at the Palmer House, Nov. 14, at 7 p.m. Prof. W. Trinks, of the Carnegie Institute of Technology, will give a talk on "Some Observations on European and American Steel Plants," and there will be other discussions on iron and steel subjects.

A. S. M. E. — Philadelphia Section. Meeting, Nov. 27. Subject: "Conowingo Hydro-Electric Development," by Alexander Wilson, 3rd, Assistant Chief Engineer, The Philadelphia Electric Company.

Coming Conventions

American Institute of Electrical Engineers, annual winter convention, New York City, Jan. 28-Feb. 1; annual summer convention, Swampscott, Mass., June 24-28; F. L. Hutchinson, secretary, 33 West 39th St., New York City.

American Institute of Refrigeration, at Washington, May, 1929. Louis Baron, secretary, 203 West 13th St., New York City.

American Society of Heating and Ventilating Engineers, 35th annual meeting, Chicago, Ill., Jan. 28-31, 1929. A. V. Hutchinson, secretary, 29 West 39th St., New York City.

American Society of Mechanical Engineers, annual meeting, in New York City, Dec. 3-7. Calvin Rice, secretary, 33 West 39th St., New York City.

American Society of Refrigerating Engineers, at New York City, Dec. 2-6, 1928. David S. Fiske, secretary, 37 West 39th St., New York City.

Association of Iron and Steel Electrical Engineers, 25th annual convention, Pittsburgh, Pa., June 17-22, 1929. A. A. Stewart, secretary, Pittsburgh Steel Co., Monnessen, Pa.

Master Boiler Makers Association, at Atlanta, Ga., May 21-24. H. D. Vought, secretary, 26 Cortlandt St., New York City.

Midwest Power Conference and Exhibition, at Chicago, Feb. 12-16; G. E. Pfisterer, secretary, 53 West Jackson Blvd., Chicago.

National Association Practical Refrigerating Engineers, annual convention at Louisville, Kentucky, Nov. 20-23; E. H. Fox, secretary, 5707 West Lake St., Chicago, Ill.

National Exposition of Power and Mechanical Engineering will be held at the Grand Central Palace, New York City, Dec. 3-8. Address inquiries to the International Exposition Company, Grand Central Palace, New York City.

Second Bituminous Coal Conference will be held at Pittsburgh, Nov. 19-22.

A. S. H. & V. E.—Philadelphia Chapter. Meeting Nov. 8. The speaker will be F. C. Houghten, Director of Research Laboratory of the American Society of Heating and Ventilating Engineers, whose subject will be "Work of the Research Laboratory of the American Society of Heating and Ventilating Engineers."

Engineers' Club of St. Louis — Meeting, Nov. 14. Lecture on "Welded Steel Buildings" by Prof. F. P. McKibben, General Electric Company.

Business Notes

The Kennedy-Van Saun Manufacturing & Engineering Corporation, of New York City, has formed the Kennedy-Van Saun Company of Illinois, with offices in the State Bank Building, 120 South LaSalle St., Chicago. T. J. Shearer will be the manager in charge.

The Prest-O-Lite Company, New York City, announces a new Prest-O-Lite gas plant at 3155 27th Ave. N., Birmingham, Ala., which began operations Oct. 16, 1928. This plant will supply the local demand for dissolved acetylene in oxyacetylene welding and cutting. With this addition the Prest-O-Lite chain now numbers 34 acetylene producing plants situated in industrial centers throughout the country.

The Roller-Smith Company of New York announces the appointment of Arthur H. Abbott, Inc., 88 Broad St., Boston, Mass., as its district sales agent for the New England territory.

The Old Dominion Public Service Corporation, of Marion, Va., it has lately been announced, has been chartered to construct, maintain and operate all kinds of water, electric, steam and other power plants. R. M. Mead, of Cleveland, Ohio, is president of the corporation.

Gerard Swope, president of the General Electric Company, Schenectady, N. Y., announces that sales billed by the company for the first nine months of 1928 amounted to $242,676,762.07, compared with $225,959,610.89 for the corresponding period of 1927. Profit available for dividends on common stock for the first nine months of 1928 was $38,841,625.31, compared with $35,193,054.70 for the same period last year.

Huron Industries, Incorporated, manufacturer of speed reducers, seal rings and flexible couplings, has moved the general sales office from Alpena, Mich., to the Builders Building, Chicago, Ill. H. W. Munday has been appointed general sales manager, with offices in Chicago.

The W. C. West Company, of Chicago, Ill., announces that it will be represented by the following agents in various parts of the country: Minnesota, Fred A. Otto Company, 1509 Branston St., St. Paul; Michigan, M. S. Dennett Company, 334 Lexington Bldg., Detroit; California, Collins Western Corporation, 704-5 Hollingsworth Bldg., Los Angeles; Louisiana, Equitable Equipment Company, 410 Camp St., New Orleans,

Trade Catalogs

Deaërating Heaters — The Cochrane Corporation, Philadelphia, Pa., has just issued Bulletin No. 681, dealing with the subject of deaërating heaters. The bulletin covers 42 pages and describes, with the aid of many illustrations, the application of these heaters to all classes of service, from the smallest building installations to the largest examples found in central-station practice. The bulletin contains many flow and layout diagrams, and in the back pages it reprints from *Power* two articles: "Calculating Station Heat Balance," by E. B. Hyde, Jr., and M. A. Guigou, and "Characteristics of the Extraction Turbine," by Robert R. Walden.

Fabroil Gears—The General Electric Company, Schenectady, N. Y., has issued a 32-page bulletin on the subject

Fuel Prices

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; mine run, except Pittsburgh gas slack:

Bituminous (Net Tons)	Market Quoting	Price per Ton
Navy Standard	New York	$2.35@$2.60
Kanawha	Columbus	1.35@ 1.75
Smokeless	Cincinnati	2.25
Smokeless	Chicago	2.25
S. E. Kentucky	Chicago	1.35@ 1.60
Steam	Pittsburgh	1.65@ 1.80
Gas Slack	Pittsburgh	1.00@ 1.20
Big Seam	Birmingham	1.25@ 1.50
Anthracite (Gross Tons)		
Buckwheat	New York	$2.75@$3.00
Barley	New York	1.25@ 1.75

FUEL OIL

New York—Nov. 1, f.o.b. Bayonne, N. J., 28@34 deg., Baumé, industrial use, tank-car lots, 4⅜c. per gal.; 36@40 deg., furnace, tank-car lots, 6½c. per gal.

St. Louis—Oct. 24, tank-car lots, f.o.b. St. Louis, 24@26 deg., $1.37 per bbl. or 42 gal.; 26@28 deg., $1.42 per bbl.; 28@30 deg., $1.47 per bbl.; 30@32 deg., $1.52 per bbl.; 32@36 deg., gas oil, 4.151c. per gal.; 38@40 deg., 5.105c. per gal.

Pittsburgh—Oct. 23, f.o.b. local refinery, 30@34 deg., fuel oil, 5c. per gal.; 36@40 deg., 5½c. per gal.

Philadelphia—Oct. 25, 26@30 deg., $1.89@$1.96 per bbl. or 42 gal.; 13@19 deg., $0.95@$1.02 per bbl.; 22 plus. $1.43@$1.50 per bbl.; 27@30 deg., $2.00@$2.07 per bbl.

Cincinnati—Oct. 29, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 5c. per gal.; 26@30 deg., 5½c. per gal.; 30@32 deg., 5.95c. per gal.

Chicago—Oct. 20, tank-car lots, f.o.b. Oklahoma, freight to Chicago, 90c. per bbl. or 42 gal.; 22@26 deg., 65c. per bbl.; 26@30 deg., 75c. per bbl.; 30@32 deg., 97½c.@$1 per bbl.

Boston—Oct. 29, tank-car lots, f.o.b. 12@14 deg. Baumé, 4.56c. per gal.; 28@32 deg., 5.65c. per gal.

Dallas—Oct. 27, f.o.b. local refinery, 26@30 deg., $1.15 per bbl. or 42 gallons.

of silent Fabroil and Textolite gears. The publication describes the process by which the gears are made and gives considerable application data helpful in determining what classes of duty fabric gears can perform.

PORTABLE COMPRESSORS—Bulletin No. 787, issued by the Chicago Pneumatic Tool Company, New York City, deals with electric-motor-driven compressors mounted on small trucks for use in various classes of street repair work, etc. The publication covers twelve pages, and carries many illustrations.

INDUSTRIAL BUILDINGS—A 36-page bulletin recently issued by the Blaw-Knox Company, Pittsburgh, Pa., goes into the subject of standardized industrial buildings of copper-bearing galvanized steel. The publications illustrates many types of building and gives some data as to dimension and applications.

ELECTRIC HOISTS—The Sullivan Machinery Company, 30 Church St., New York City, has recently issued a bulletin on portable electric hoists, showing the use of these hoists in manipulating drag buckets for handling coal, etc. The bulletin, No. 76-J, is well illustrated and shows many installation views of the Sullivan equipment.

CRANES—The Cleveland Crane & Engineering Company, Cleveland, Ohio, has just issued Catalog No. C-100, a sixteen-page publication describing various types of traveling cranes and their application. The back of the catalog contains some useful illustrations showing methods of attaching crane hooks to various objects.

INDUCTION MOTORS — The Wagner Electric Corporation of St. Louis, Mo., has issued a new bulletin describing its large type RA single-phase repulsion-induction motors. The bulletin is fully illustrated, and a detailed description of every part of the motor is given. Not only is the motor picked to pieces to make clear to motor users what each part is for and why it is made that way, but there is much general information covering such subjects as types of single-phase motors, history of repulsion-induction motors (from the first hand-cranked motor to the present self-starting, self-ventilated type), operating principles (both electrical and mechanical, with torque-speed-current curves and cross-sectional diagrams of the motor), sleeve and ball-bearing construction (illustrated with cross-section diagrams and photos), ventilation, and construction features of stator, end plate, rotor and rocker arm. The bulletin contains twelve pages.

TURBINE BLOWERS—Under the title "Improved Gas Producer Operation," the L. J. Wing Manufacturing Company, of New York City, has issued a little booklet of sixteen pages, which describes the producer-gas process and shows how the turbine blower may be applied to increase the efficiency of gas production.

BOILERS—In a new catalog just issued by the Union Iron Works, of Erie, Pa., the subject of longitudinal-drum water-tube boilers is thoroughly covered. The catalog consists of 53 pages describing the company's products, giving many illustrations and including general descriptive text. A feature of special interest is a group of blueprint reproductions of boiler installation diagrams at the back of the publication.

New Plant Construction

COMPILED BY THE MCGRAW-HILL BUSINESS NEWS DEPARTMENT, WHICH IS PREPARED TO FURNISH A MORE COMPLETE DAILY SERVICE TO THOSE WHO WISH IT

Calif., Long Beach—W. L. Porterfield, awarded contract for a 5 story office building at Ocean Blvd. and Pine Ave. to Meyer & Holler, Wright and Collender Bldg., Los Angeles. Estimated cost $600,000. Steam heating system, elevators, etc. will be installed.

Calif., Los Angeles—Charlemagne Corp., plans the construction of a 10 story apartment building including steam heating system, elevators, etc. at Cherokee and Yuca Sts. Estimated cost $700,000. MacDonald & Bryant, 316 Spring Arcade Bldg., are architects.

Calif., Los Angeles—Los Angeles Printing Building, Inc., is having preliminary plans prepared for the construction of a 12 story printing plant at 8th and Crocker Sts. Estimated cost $1,500,000. W. D. Lee, 315 East 8th St., is architect. C. M. Church, 1070 Le Claire St, is interested.

Calif., Los Angeles—W. J. Saunders, 787 East Pico St., Archt., is preparing plans for the construction of a laundry including 40 x 50 ft. boiler room, etc., at 1621 South San Pedro St. Estimated cost $100,000. Owner's name withheld.

Calif., Los Angeles—Sun Realty Co., 727 West 7th St., will receive bids until Nov. 15, for the construction of a 12 story office and stores building including steam heating system, elevators, etc., at 8th and Hill Sts. Estimated cost $800,000. C. Beelman, 1019 Union Bank Bldg., is architect.

Calif., San Diego — Bureau of Yards & Docks, Navy Dept., Washington, D. C., awarded contract for addition to power house at Radio Station. Chalias Heights, Naval Operating Base here to Wurster Construction Co., 231 Spreckles Theatre Bldg.

Calif., San Rafael—E. W. Smith, Clk., will soon award contract for outfall sewer and pumping plant. H. K. Brainerd is city engineer.

Calif., San Francisco — Shell Co. of California, 200 Bush St., plans the construction of an office building at Bush and Battery Sts. Estimated cost $2,000,000. Architect not selected.

Colo., Denver—City and County awarded contract for a 5 story court house and city hall at Bannock between West 14th and West 15th Sts., to Varnum & Bate, 2311 10th St. Estimated cost $5,000,000. Steam heating system, etc. will be installed.

Conn., Bridgeport — Bridgeport Hospital, Grant St., plans the construction of a hospital including addition to nurses' home, maternity ward, boiler house, etc. on Grant St. Estimated cost $500,000. E. B. Caldwell, 886 Main St., is architect.

D. C., Washington—Industrial Realty Co., (Southern Railway Co.) 13th and Pennsylvania Ave. N.W., awarded contract for an 11 story office building at 15th and K Sts. N.W. to Consolidated Engineering Co., 20 East Franklin St., Baltimore, Md. Estimated cost $1,250,000. Vacuum heating system, electric elevators, etc. will be installed.

Ill., Chicago—City Council and Sanitary Dist. of Chicago, R. J. Crowe, Pres., 910 South Michigan Ave., signed ordinance for the construction of South Side sewage system including pumping station. Estimated cost approximately $28,000,000.

Ill., Chicago — H. Jansen, 307 North Michigan Ave., is having sketches made for a 20 story hotel at Illinois and Rush Sts. Estimated cost $1,750,000. W. Bernhard & Co., 820 Tower Ct., are architects.

Idaho, Twin Falls—City awarded contract for the construction of a new electric power sub-station to Ernest White & Co. Estimated cost $20,000.

Ia., Des Moines — Syndicate, c/o E. B. Winnett, 2930 Cottage Grove Ave., is having preliminary plans prepared for a 12 story medical arts building including steam heating system, etc. Estimated cost $1,500,000. Normile & Emery, 604 Hubbell Bldg., are architects.

Ky., Louisville — A. E. Black & Co., Lauderman Bldg., St. Louis, Mo., plans an 18 story addition to hotel at 218 West Broadway. Estimated cost $2,400,000. Private plans.

La., Sulphur—City awarded contract for waterworks improvements including pump house, pumps, mains, etc., to S. B. Stewart, Baton Rouge. Estimated cost $55,000.

Mass., Boston—United Shoe Machine Co., S. W. Winslow, Jr., Chn. Bldg. Comn., 205 Lincoln St., will receive bids until Nov. 14, for a 24 story office building at 138-162 Federal St. Parker, Thomas & Rice, 177 State St., are architects. French & Hubbard, 210 South St., are engineers.

Mass., Cambridge (Boston P. O.)—City, J. J. Scully, Chn. Water Board, City Hall, received lowest bid for the construction of a pumping station at Lake View Ave. and Worthington St., from J. Slotnick, 199 Washington St., Boston. $41,000.

Mass., Malden (Boston P. O.) — Boston Ice Co., 11 Deerfield St., Boston, will soon award contract for the construction of a 125 x 150 ft. ice plant at Philips Court. Estimated cost $75,000. Private plans.

Mass., Malden (Boston P. O.) — Malden Hospital, E. P. Bliss, is having preliminary sketches made for the construction of a 5 story hospital on Hospital Rd. Estimated cost $1,200,000. Kendall, Taylor & Co., 142 Berkley St., are architects.

Mich., Detroit — Bd. of Water Comrs., F. P. Book, Pres., will receive bids until Nov. 14, for the construction of an auxiliary low lift pumping plant at Waterworks Park. G. H. Fenkell, is general manager and chief engineer.

Mich., Detroit—Detroit Edison Co., 2000 Second Blvd., is having plans prepared for the construction of a coaling station to include hoppers and coal handling equipment, etc., on Dequindre St. Estimated cost $450,000. Private plans.

Minn., Minneapolis—Northwest National Bank, will receive bids about Nov. 7 for the construction of a 16 story bank and office building. Estimated cost $2,000,000. Graham, Anderson, Probst & White, 80 East Jackson Blvd., Chicago, Ill., are architects.

Miss., Hattiesburg—State Teachers College, c/o Mississippi State Bldg. Comn., W. C. Trotter, Secy., Jackson, will receive bids until Nov. 22, for the construction of an administration building, dormitory, power plant, etc., here. Estimated cost $470,000. V. B. Smith, Jr., Real Estate Bldg., Gulfport, is architect.

Miss., Oxford—University of Mississippi, c/o Mississippi State Bldg. Comn., Jackson, is having plans prepared for a group of college buildings, including pump house, etc., here. Frank P. Gates Co., Edwards Hotel Bldg., is architect.

Mo., St. Louis — Bd. of Education, 911 Locust St., will receive bids about Feb. 1, for the construction of a vocational school including steam heating system, etc. Esti-

mated cost $1,500,000. R. M. Milligan, c/o Bd. of Education, is architect and engineer.

Mo., St. Louis—Paramount Construction Co., 904 Chestnut St., plans the construction of a 15 story apartment building at 4436 Lindell Boulevard. Estimated cost $1,000,000.

Mo., St. Louis—Sovereign Building & Investment Co., A. A. Spiel, Pres., c/o N. B. Howard and N. C. Finley, International Life Bldg., Archts., is having preliminary plans prepared for an 18 story apartment building including steam heating system, etc. at Lindell St. and Euclid Ave., Estimated cost $1,250,000.

Mo., Trenton—City plans extensions and improvements to light and power plant. Burns & McDonnell, 401 Interstate Bldg., Kansas City, Mo., are engineers.

N. J., Belleville (br. Newark)—Bd. of Freeholders, Hall of Records, Market St. and Springfield Ave., Newark, is having plans prepared for the construction of an 8 story hospital and nurses' home, including steam heating, ventilation and refrigeration systems, boilers, elevators, etc., here. Estimated cost $1,000,000. Sutton, Sutton & Calkins, 402 Broad St., Newark, are architects. Runnors & Carey 31 Fulton St., Newark, are engineers.

N. J., Highlands—Borough Council, will receive bids until Nov. 26, for the construction of a sewage treatment plant and three pumping stations in connection with sewerage system. Remington & Vosbury, 509 Cooper St., Camden, are consulting engineers.

N. J., Piscataway town — Public Service Electric & Gas Co., Terminal Bldg., Newark, awarded contract for a 1 story, 50 x 100 ft. meter and compressor building, here, to George B. Rule Inc., 71 John St., New Brunswick. Estimated cost $40,000.

N. Y., Albany—New York Power & Light Corp., subsidiary of Mohawk-Hudson Power Corp., 126 State St., plans the construction of a transmission line, 54 mi. to include sub-station. Estimated cost $838,000.

N. Y., Brooklyn — Dept. of Mental Hygiene, Albany, received lowest bid for remodeling power house and pump room at Brooklyn State Hospital here from Balaban-Gordon Co., Inc., 116 West 39th St., New York, $17,720.

N. Y., New York—Central Park Properties Inc., 1351 Broadway, awarded contract for a 19 story apartment building at 153 West 58th St. to A. E. Lefcort, 1351 Broadway. Estimated cost $4,000,000.

N. Y., New York — Lillie R. Weinberg, 390 West End Ave., plans the construction of a 20 story bank and office building at 400 Madison Ave. Estimated cost $1,250,000. H. C. Severance, 36 West 44th St., is architect.

N. Y., New York — Madison Ave. and 52nd St. Corp., c/o J. E. R. Carpenter, 578 Madison Ave., Archt., awarded contract for a 25 story office and stores building at Madison Ave. and 52nd St. to Dwight P. Robinson, 125 East 46th St. Estimated cost $1,000,000.

N. Y., New York — New York Steam Corp., 280 Madison Ave., awarded contract for the construction of 9 story warehouse at foot of East 36th St., to Turner Construction Co., 420 Lexington Ave.

N. Y., New York—One Forty-Nine East 47th St. Corp., T. Crimins, Pres., 734 Lexington Ave., awarded contract for the construction of a 15 story apartment building, to G. Richard Davis & Co., 10 East 41st St. Estimated cost $1,500,000.

N. Y., West New Brighton — Sisters of Charity of St. Vincent, Mt. St. Vincent on Hudson, will soon award contract for the construction of a hospital at Castleton and Bard Aves., here. Estimated cost $1,000,000. Ditmars & Reilly, 111 5th Ave., New York, are architects.

O., Cleveland—Cleveland Hotel Co., M. J. Van Sweringer, Pres. and Gen. Mgr., is having plans prepared for the construction of a 10 story hotel on Public Sq. Estimated cost $4,000,000. Graham, Anderson, Probst & White, Railway Exch. Bldg., Chicago, Ill., are architects.

O., Marion — Columbus, Delaware & Marion Electric Co., A. F. Van Deinse, Pres., plans addition to Scioto power plant. Estimated cost $400,000.

O., Willoughby—City Ice & Fuel Co., c/o C. C. Coneby, 6611 Euclid Ave., Cleveland, is having plans prepared for a 11 story, 100 x 100 ft. ice plant. Estimated cost $100,000. Private plans.

Okla., Coyle—Taylor-Easterling & Co., Inc., Kennedy Bldg., Tulsa, plans the construction of a 10 ton raw water ice plant here. Estimated cost $25,000. Private plans.

Okla., Lexington—H. E. Walker and E. L. Ambuster, Puncell, plan the construction of an ice plant here. Estimated cost $25,000. Private plans.

Pa., Wilkes-Barre—Wilkes-Barre School Dist., F. Siedfried, 93 Washington St., will soon award contract for the construction of a 52 x 88 ft. boiler house at Carey Ave. and Hanover St. Estimated cost $80,000. R. Ireland, 383 North Washington St., is engineer.

Texas—Cameron County Water Improvement Dist. 10, Brownsville, voted $680,000 bonds for the construction of a pumping station, etc., in connection with irrigation system. W. O. Washington is county engineer.

Tex., Galveston — American National Insurance Co., c/o S. Moody, Pres., is receiving bids for an 11 story office building including steam heating, ventilation and refrigeration systems, boilers, elevators, etc. Estimated cost $600,000. A. Fraser, 624 American Insurance Bldg., is architect.

B. C., Vancouver—British Columbia Pulp & Paper Co. Ltd., plans a power development at Port Alice plant. Estimated cost $500,000.

B. C., Victoria—Victoria Cold Storage & Terminal Warehouse Co. Ltd., awarded contract for the construction of a cold storage plant and warehouse at Ogden Point to Parfitt Bros. Ltd., 1303 Gladstone Ave. Estimated cost $400,000. This corrects report in Oct. 9 issue.

Ont., Capreol—City Council, plans election to vote $30,000 bonds for pump, wells, etc. in connection with waterworks and sewage systems.

Que., Montreal — City is having plans prepared for the construction of a new pumping station, including electrically driven pumps and operating appliances, etc. Estimated cost $700,000 to $800,000. H. A. Terreault is city engineer.

Russia, Union Soviet Socialist Republica—Russian Government, c/o Amtorg Trading Corp., 165 Broadway, N. Y., awarded contract for electrical apparatus for a period of six years to International General Electric Co., 120 Broadway, New York, N. Y. Estimated cost approximately $21,000,000 to $26,000,000.

Equipment Wanted

Boiler Room Equipment—Bd. of Public Works, San Francisco, Calif., will receive bids until Nov. 14 for additional equipment for boiler room, shop and academic departments of Polytechnic high school on Frederick St. Estimated cost $15,000.

Electrical Equipment—Bureau of Yards & Docks, Navy Dept., Washington, D. C., electrical equipment including lighting systems, wires, cables, conduits, transformers, etc. at Naval Operating Base (Air Station) San Diego, Calif.

Generator—M. B. Beatty, Clk., Los Angeles, Calif., will receive bids until Nov. 19 for a 400 kw. motor generator set for Hall of Records.

Power Pumping System—A. L. Flint, General Purchasing Officer of the Panama Canal, Washington, D. C., will receive bids until Nov. 19 for power pumping system, etc.

Pump—Bd. of Water Comrs., F. B. Book, Pres., Detroit, Mich., will receive bids until Nov. 12, for a 40 m.g.d. single stage electric motor driven centrifugal pumps direct connected to synchronous electric motor and exciter for pumping station No. 1 at Waterworks Park.

Pumping Equipment — City of Alpine, Tex., pumping equipment for proposed waterworks improvements. Estimated cost $75,000.

Pumping Equipment — City of Hughes, Ark., pumping equipment, etc., for proposed waterworks and distribution systems.

Pumps — City, F. Fowler, Clk., Maud, Okla., will receive bids until Nov. 9 for two motor driven centrifugal pumps and one marine engine driven centrifugal pump for proposed waterworks improvements. Estimated cost $20,000.

Refrigeration Equipment — Bureau of Yards & Docks, Navy Dept., Washington, D. C., will receive bids until Nov. 7 for automatic refrigeration equipment.

Refrigeration Equipment, Compressor, etc. — Dept. of Mental Hygiene, Albany, N. Y., will receive bids until Nov. 21, for refrigeration equipment, compressor, etc. at Brooklyn State Hospital, Brooklyn, N. Y.

Industrial Projects

Calif., San Mateo—FACTORY—San Francisco Aircraft Specialty Corp., J. R. Gilbert, 408 Warren Road, plans the construction of a factory. Estimated cost $50,000. Architect not selected.

Calif., Van Nuys — AEROPLANE FACTORY—Bach Aircraft Co., c/o M. B. Falk, 1008 Washington Bldg., Los Angeles, Archt., will soon award contract for the construction of a 100 x 200 ft. factory including paint shop here. Estimated cost $40,000.

Conn., East Hartford—FACTORY—Capitol Parlor Frame Co., 470 Tolland St., Hartford, had plans prepared for a 1 story, 60 x 220 ft. factory. Estimated cost $45,000. G. Zunner, 1082 High St., Hartford, is architect.

Ky., Frankfort — CEMENT PLANT — Kentucky Cement Corp., is having plans prepared for the construction of a cement plant. Estimated cost $2,500,000. Hunt Engineering Co., 701 New York Life Bldg., Kansas City, Mo., is engineer.

Mich., Battle Creek—THRESHING MACHINE FACTORY—Nichols & Shepard Co., Marshall and G. T. R. R., awarded contract for a 1 story, 100 x 400 ft. factory to Ralph Sollitt, Battle Creek. Estimated cost $300,000. Equipment will be installed.

Mich., Detroit—BOLT and SCREW FACTORY—Ajax Bolt & Screw Co., 6623 Gratiot Ave., is having plans prepared for a 2 story bolt and screw factory. Estimated cost $50,000. Private plans. Equipment will be required.

Mich., Detroit — AUTOMOBILE BODY FACTORY—Briggs Mfg. Co., 11639 Mack Ave., awarded contract for a 2 and 3 story, 575 x 700 ft. addition to automobile body plant at St. Jean and East Warren Sts. Otto Misch Co., 159 East Columbia St. Also a 5 story, 200 x 350 ft. addition at Cleveland, O., to S. W. Emerson Co., 1836 Euclid Ave., Cleveland, O. $40,000.

Mich., Detroit—FOUNDRY EQUIPMENT FACTORY—Holcroft & Co., 6545 Epworth Blvd., is having plans prepared for a 1 and 2 story, 105 x 180 ft. factory on Westwood Ave. C. L. Phelps, 504 Detroit Savings Bank Bldg., is architect.

N. C., Asheville—RAYON PLANT—American Enka Co., A. F. L. Moritz, V. Pres. and Ch. Engr., 114 East 32nd St., New York, N. Y., and Asheville, N. C., awarded contract for the construction of a group of buildings for rayon plant including four main buildings, 1100 x 1500 x 400 ft., chemical storage building, service building, boiler house, turbine building and filter house here to H. K. Ferguson Co., Hanna Bldg., Cleveland, O. Estimated cost approximately $10,000,000.

O., Cleveland—BRASS MANUFACTURING PLANT—The Royal Brass Mfg. Co., 1420 East 43rd St., awarded contract for a 1 story, 34 x 132 ft. factory. Estimated cost $40,000.

O., Salem—RADIATOR and AUTOMOBILE BODY FACTORY—Millins Manufacturing Co., plans addition to factory. Estimated cost $50,000 to $75,000.

Pa., Philadelphia — RADIO FACTORY ADDITION—Atwater Kent Mfg. Co., 4700 Wissahickon Ave., will soon receive bids for addition to radio factory. Estimated cost $1,000,000. Ballinger Co., 105 East 12th St., is architect.

Ont., Toronto—HEAT MANUFACTURING PLANT and RADIATOR and BOILER PLANT—Dominion Radiator & Boiler Co., 1322 Dufferin St., plans the construction of a heat manufacturing plant, also a 1 and 2 story radiator and boiler plant at Brantford. Estimated cost $300,000 and $200,000 respectively. Architect not selected.

Ont., Kitchener—AUTOMOBILE TIRE FACTORY—Canadian Goodrich Co., J. W. Jordan, Mgr., is having plans prepared for addition to automobile tire factory on King St. W. Estimated cost $250,000.

Ont., Windsor — AUTOMOBILE FACTORY—Chrysler Corp. of Canada, J. D. Mansfield, Mgr., 300 Tecumseh Rd., is having plans prepared for the construction of an automobile factory and truck plant on Tecumseh Rd. Estimated cost $1,500,000. Hutton & Souter, 6 James St. S., Hamilton, are architects.